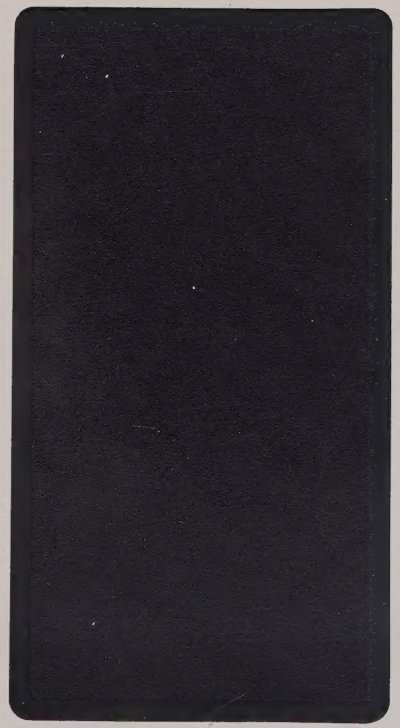
INSTRUCTION MANUAL

MODEL 240A

HIGH VOLTAGE SUPPLY

KEITHLEY INSTRUMENTS



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HIGH VOLTAGE SUPPLY

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof (except tubes and batteries) which, within a year after shipment, proves defective upon examination. We will pay domestic surface freight costs.

To exercise this warranty, call your local field representative or the factory, DDD 216-248-0400 You will be given assistance and shipping instructions.

REPAIRS AND RECALIBRATION

Keithley Instruments maintains a complete repair service and standards laboratory in Cleveland, and has an authorized field repair facility in Los Angeles.

To insure prompt repair or recalibration service, please contact your local field representative or the plant directly before returning the instrument.

Estimates for repairs, normal recalibrations, and calibrations traceable to the National Bureau of Standards are available upon request.

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*Change Notice	Last Page

*Yellow change notice sheet is included only for instrument modifications affecting the Instruction Manual

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Keithley Model 240A is a compact high voltage supply which provides accurate, stable outputs from 0 to 1200 volts dc. Accuracy is ±1% of the dial setting for all outputs. Stability is ±0.02% ± 2 millivolts the first hour or in subsequent 8-hour periods, after a 30-minute warm-up. Line regulation is ±0.005% ± 2 millivolts for a 10% change in line voltage, and load regulation is ±0.005% ± 2 millivolts from no load to full load.

1-2. FEATURES.

a. Three in-line calibrated dials set the output voltage in 1-volt steps. A TRIM Control permits interpolation between steps with better than 5-millivolt resolution. Output can be selected positive or negative with respect to ground.

b. Repeated overloading or operation in an overloaded condition for long periods will not damage the Model 240A. Overload protection limits the output current to less than 13 milliamperes and, when the overload is removed, automatically returns the Supply to its set value.

c. The circuit for the Model 240A takes advantage of the reliability and stability of a solid-state comparator amplifier, and the high voltage capability of a series regulator tube to provide a high performance circuit. Metal-film range resistors and a selected zener diode contribute to its overall accuracy and stability.

1-3. APPLICATIONS.

a. In the laboratory the Model 240A is a general-purpose high voltage supply. Applications include use in surface and volume resistivity measurements and with high resistance bridges. The Model 240A will supply operating potentials for photomultiplier tubes, electron multipliers, solid-state radiation detectors and ionization chambers. It can also be used in the calibration of meters and electrostatic probes.

b. Typical production testing applications are semiconductor and capacitor leakage measurements. The output of the Voltage Supply may be remotely controlled or programmed by adding a connector to the rear panel. A mounting hole is provided to easily modify the Model 240A.

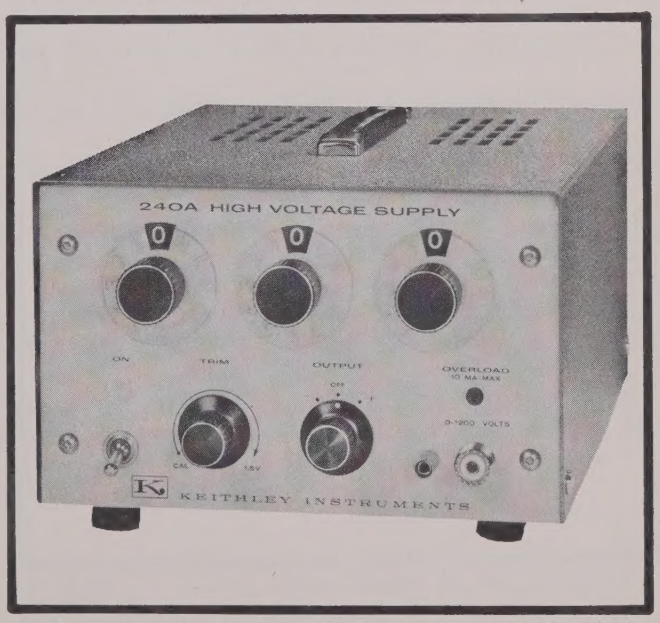


FIGURE 1. Keithley Instruments Model 240A High Voltage Supply.

1-4. ACCESSORIES.

a. Model 4003A Rack Mounting Kit adapts the Model 240A for standard 5-1/4 inch x 19 inch rack mounting.

b. Model 4004A Dual Rack Mounting Kit adapts two Model 240A's for side-by-side

standard 5-1/4 inch x 19 inch rack mounting. The Kit will accomodate any two 5-1/4 inch high Keithley half-rack Models.

1-5. SPECIFICATIONS.

OUTPUT:
Voltage: 0 to 1200 volts dc in 1-volt steps.
Current: 10 milliamperes dc maximum.
Polarity: Positive or negative with respect to chassis.

ACCURACY: ±1% of dial setting.

RESOLUTION: A TRIM Control permits interpolation between steps with a resolution of better than 5 millivolts.

STABILITY: ±0.02% ± 2 millivolts the first hour or in subsequent 8-hour periods, after a 30-minute warm up.

LINE REGULATION: ±0.005% ± 2 millivolts for 10% change in line voltage.

LOAD REGULATION: ±0.005% ± 2 millivolts from no load to full load.

RIPPLE AND NOISE: Less than 1 millivolt rms above 5 cps.

RECOVERY TIME: No load to full load, less than 35 milliseconds to within 0.1% of no-load output.

OVERLOAD PROTECTION:

Electronic current limiting to less than 13 milliamperes within 15 milliseconds for 200% or greater overloads.

Automatic recovery from overload to within 1% of no-load output within 1/4 second at 1200 volts. Proportionally faster at lower voltages.

CONNECTORS: Output: Teflon-insulated uhf type.

POWER: 105-125 or 210-250 volts, 50-60 cps, 65 watts.

DIMENSIONS, WEIGHT: 5-1/2 inches high x 8-3/4 inches wide x 13 inches deep; net weight, 12 pounds.

ACCESSORIES SUPPLIED: Mating output connector.
3:2 adapter for power line

1-6. EQUIPMENT SHIPPED. The Model 240A is factory calibrated and is shipped for bench use. A mating connector and Instruction Manual are also in the shipping carton.

SECTION 2. OPERATION

2-1. FRONT PANEL CONTROLS AND TERMINALS. (See Figure 2.)

a. ON Switch. A toggle switch turns on the line power to the entire instrument. Turning the Switch off removes the output power within a short time.

b. ON Pilot Light. The ON Pilot Light glows orange to indicate the Voltage Supply is on, whatever the setting of any control.

c. Voltage Dials. Three skirted dials, calibrated in 100, 10 and 1-volt steps, set the output voltage from 0 to 1200 volts dc. Note the first dial can be set to 11, the other two can be set to 10.

d. TRIM Control. The TRIM Control interpolates between 1-volt settings of the Voltage Dials with better than 5-millivolt resolution. The span of the Control is 1.5 volts. The Control has a snap-action CAL position; at this setting the Model 240A output is determined only using the Voltage Dials.

e. OUTPUT Switch. This Switch selects either positive or negative outputs with respect to chassis ground. In the OFF position, there is no output voltage although the instrument is operating. When the Switch is in OFF position, a 220-kilohm resistor shunts the Output Terminals to discharge any capacitive loads present.

f. Output Receptacle. A Teflon-insulated uhf receptacle is mounted on the front panel to supply the output voltage. The shell of the Receptacle is connected to chassis ground. The adjacent binding post allows connectors other than uhf type to be used.

g. OVERLOAD Lamp. The OVERLOAD Lamp comes on when the output current exceeds approximately 11 milliamperes; it remains on until the overload condition is removed.

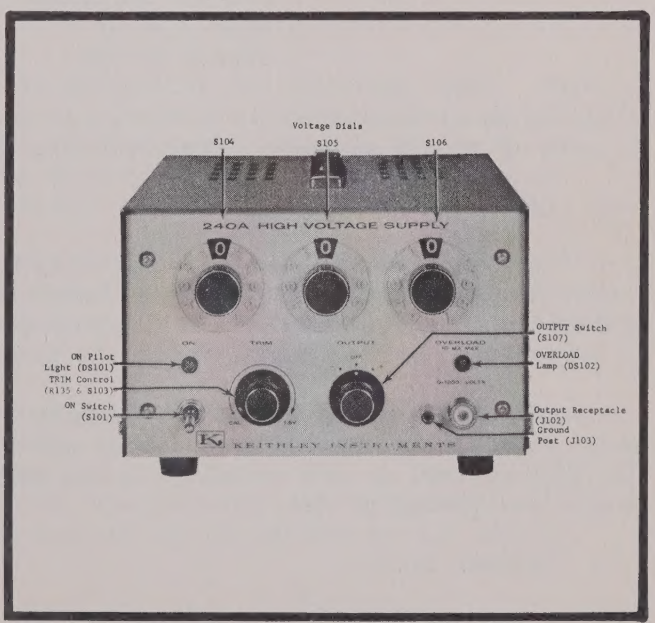


FIGURE 2. Model 240A Front Panel Controls and Terminals. The designations refer to the Replaceable Parts List and schematic diagram

2-2. REAR PANEL CONTROLS AND TERMINALS

a. OUTPUT Receptacle. A Teflon-insulated uhf connector is mounted on the rear panel. Both the front and rear panel Output Receptacles are connected in parallel with a heavy buss.

b. 117-234 Volt Slide Switch. The screwdriver-operated slide switch sets the Model 240A for 117 or 234-volt power lines.

c. Fuse. For 105-125 volt operation, the Model 240A uses a 3/4 ampere slow-blow fuse. For 210-250 volt operation, the Model 240A uses a 3/8-ampere slow-blow fuse.

d. Covered Blank Mounting Hole. A hole is punched in the rear panel to allow moun-

ting of a Cinch-Jones connector. This hole is provided to easily modify the Model 240A for remote voltage control.

2-3. CONNECTIONS.

a. Use coaxial cables to insure good circuit connections and safe operation. Use Teflon or polyethylene-insulated connectors and cables which will withstand more than 1200 volts. Inspect insulation for mechanical or heat damage.

b. Coaxial cables also have the best noise characteristics. If noise is not important, unshielded leads may be used since the output impedance at low frequencies is very low.

c. For safety, use the 3-wire power cord to connect to power lines. Make sure the third wire is connected to a good earth ground. If ground currents flowing in the ground path prevent this, analyze the circuit. Make sure safe operation is possible even with the ground lead not connected.

2-4. PRELIMINARY PROCEDURES.

a. The Model 240A is shipped in operating condition with all components installed.

b. Check the 117-234 Volt Switch and the Fuse for the proper line voltage. Make sure the Voltage Supply will be properly ventilated when it is operating. Air flow should be available from the bottom, top and rear.

c. Set the front panel controls to:

ON Switch	off
Voltage Switches	000
TRIM Control	CAL
OUTPUT Switch	OFF

Plug the power cord into the power line. Turn the ON Switch on and allow the Model 240A to warm up for 30 minutes. The operating checks may be performed if desired.

2-5. OPERATING CHECKS.

a. Zero Balance. Connect the Keithley Model 153 Microvolt-Ammeter or an equivalent instrument to the Model 240A OUTPUT Receptacle. With the Voltage Switches at 000 and the OUTPUT Switch at -, after 30 minutes the output voltage should be less than ±1 millivolt. If it is more, see paragraph 5-3.

b. Output Voltage. Increase the Model 153 sensitivity to 10 volts or more. Set the Model 240A Voltage Dials to an output equal to full scale on the voltmeter. Make sure the TRIM Control is set to CAL. If the output is not within the accuracy of both instruments, see paragraph 5-4.

c. Current Limit.

1. Use the Model 153 as an ammeter and connect it to the Model 240A OUTPUT Receptacle. Increase the Voltage Supply output using the TRIM Control until the OVERLOAD Lamp lights. Output current should be between -11 and -13 milliamperes. If not, see paragraph 5-5.

2. Set the Model 153 to its 30-milliampere range. (If another ammeter is used, its

voltage drop must be less than 150 millivolts on a scale capable of reading 15 milliamperes.) Set the Model 240A output voltage to -100 volts. The OVERLOAD Lamp should light and the output current should be -12.5 ±0.2 milliamperes.

2-6. SETTING OUTPUT VOLTAGE.

a. The setting of the three Voltage Dials and the TRIM Control determines the magnitude of the output voltage. The specified output accuracy of ±1% of Dial setting is assured only when the TRIM Control is set to CAL. At this setting, the TRIM Control is disconnected from the output control circuit.

b. The range of the TRIM Control is from 0 to 1.5 volts. To increase the output voltage less than 20 millivolts, reduce the Voltage Dial setting 1 volt; then use the TRIM Control in the upper portion of its range. The Control has an unusable portion at the very beginning of its range due to the switch action which defines the CAL position.

c. When the OUTPUT Switch is set to OFF, the Model 240A operates as normal except it is not delivering a current to the load. Therefore, the Voltage Dials can be changed and the Model 240A can be allowed to stabilize before a load is applied. Setting the Switch to OFF shunts 220 kilohms across the output terminals to discharge any capacitive load.

d. Relatively little overshoot or undershoot occurs when switching output voltages. For critical loads, however, first turn the OUTPUT Switch to OFF. Set the output voltage and then turn the OUTPUT Switch to the desired polarity.

NOTE

The output noise when the OUTPUT Switch is set to OFF is approximately 3 millivolts rms. This is typical and does not indicate a defective Voltage Supply.

2-7. OVERLOAD OPERATION.

a. A current limiting circuit provides overload protection for the Model 240A. When output current exceeds approximately 10 milliamperes, the Model 240A enters a constant current mode; the load resistance then determines the voltage across the load. For this mode, the OVERLOAD Lamp will light. Removing the overload or reducing the load automatically resets the Model 240A output to its original value.

b. The Model 240A is factory adjusted to deliver at least 10 milliamperes before the current limiting circuit operates. The OVERLOAD Lamp lights at about 11-milliampere output. Current limiting action, indicated by an increase in output noise, begins at about 11.5 milliamperes. At short circuit maximum output current is about 12.5 milliamperes.

c. On a typical instrument, maximum short circuit output current can be adjusted anywhere between 6 and 16 milliamperes (paragraph 5-5). This provides a useful current output from about 4 to 14 milliamperes. However, operating the Model 240A at outputs greater than 10 milliamperes may degrade its load regulation specification for 1200-volt outputs and for low power-line voltages, and it may also degrade specifications at all output voltages.

NOTE

For output voltages and capacitive loads exceeding 1 joule of energy, never use the Voltage Dials to reduce the output more than 100 volts at a time or to go to zero output. Use the procedures given in paragraph 2-9.

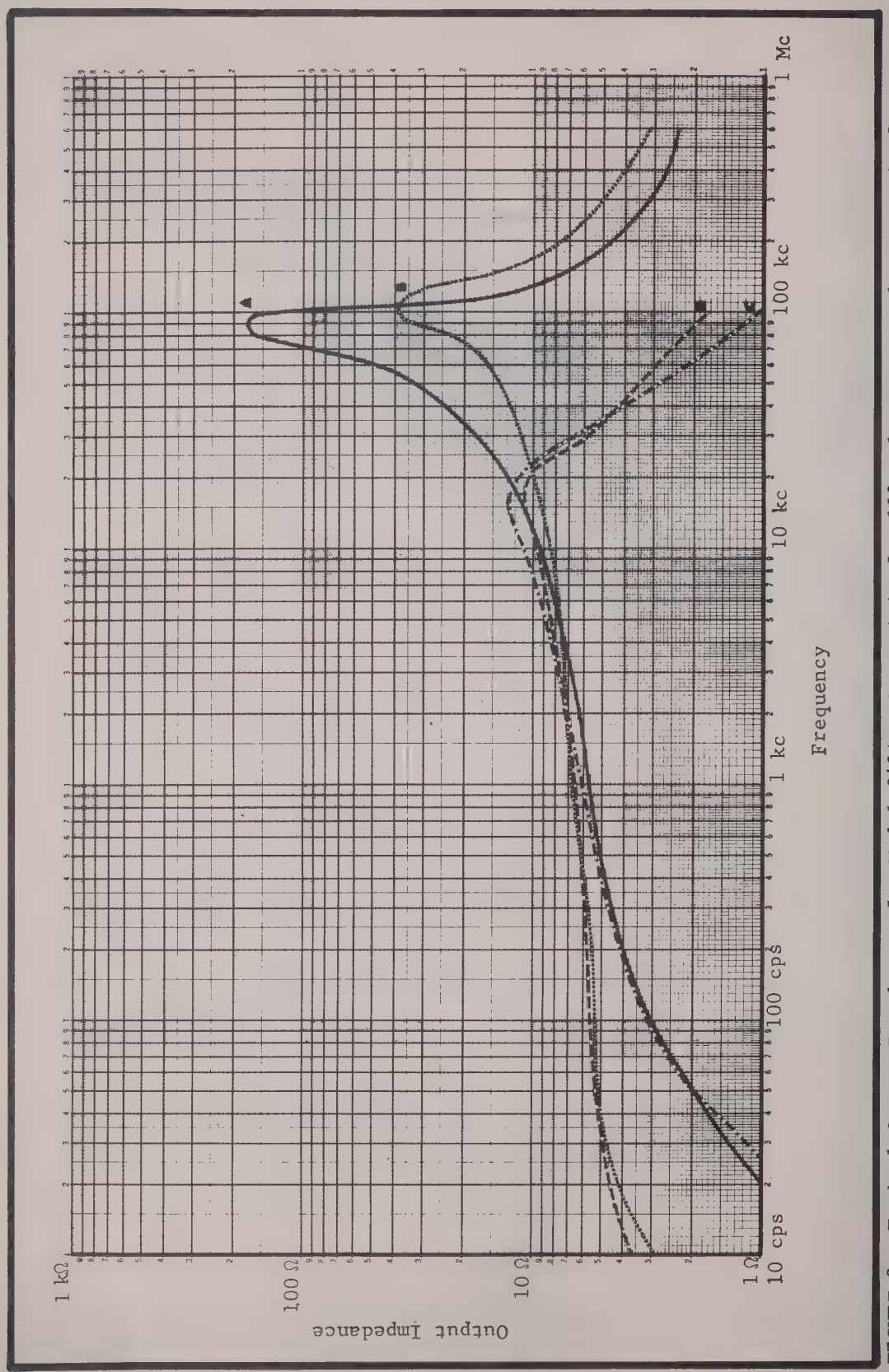


FIGURE 3. Typical Output Impedances for Model 240A. Curve A is for 100-volt output and Curve B is for 1200-volt output with only a resistive load. Curve C is for 100-volt output and Curve D is for 1200-volt output with a 1-microfarad capacitive load. These are typical values for the Model 240A with a constant 5-milliampere load.

2-8. OUTPUT IMPEDANCE. Figure 3 illustrates the typical output impedances for the Model 240A. Curves are shown for output voltages of 100 and 1200 volts with and without a 1-microfarad capacitive load. These measurements were taken at a constant 5-milliampere load.

2-9. CAPACITIVE LOADS.

a. Its current limiting circuit enables the Model 240A to charge capacitive loads without difficulty. The OVERLOAD Lamp will light during the time the output current exceeds 11 milliamperes, but the current continues to flow. The Model 240A Voltage Supply does not have to be continually reset while charging a capacitive load.

b. For capacitive loads exceeding 1 joule of energy, change the Model 240A output by first setting the OUTPUT Switch to OFF. Then readjust the Voltage Dials and turn the OUTPUT Switch to the desired polarity. Reducing the output voltage without setting the OUTPUT Switch to OFF could damage the ranging resistors and/or the voltage selection switches.

2-10. OUTPUT NOISE. When the Model 240A operates with no load and from a clean power line, typical output noise at any voltage setting will be less than 10 millivolts peak-to-peak or 0.5 millivolts rms. Transient noise on the power line will tend to increase the peak-to-peak output noise, and if it is sufficiently high, may cause the rms output noise to also increase. As the output current increases, output noise decreases to between 5 and 2 millivolts peak-to-peak.

2-11. SHORT-TERM STABILITY. After a 3-hour warm-up the short term stability of the Model 240A is typically better than 0.003% per hour for output voltages greater than 100 volts and with constant line voltage, load and ambient temperature.

2-12. TEMPERATURE COEFFICIENT. The temperature coefficient of the Model 240A output voltage depends primarily upon the temperature coefficients of the zener reference, the voltage divider resistors, and the voltage control comparator circuit. Using the maximum values for these components, the maximum temperature coefficient for the voltage supply is $\pm$258 ppm/^{o}C or $\pm$0.026%/^{o}C. Typically, the coefficient will be much lower. Table 1 shows some values which can be expected.

2-13. REMOTE PROGRAMING

a. Remote programing or control of the Model 240A is possible using one of two methods: resistance programing or voltage programing. The Model 240A can be modified for only one of these methods at a time, however. The modifications do not have to be permanent and the Model 240A can be easily returned to normal operation.

Temperature Change	Temperature Coefficient at Model 240A Voltage Setting of:		
	+100 Volts	+490 Volts	+1200 Volts
50^{o}C to 25^{o}C	-0.0008%/^{o}C	-0.0009%/^{o}C	-0.0020%/^{o}C
25^{o}C to 10^{o}C	-0.0014%/^{o}C	-0.0007%/^{o}C	+0.0017%/^{o}C

TABLE 1. Typical Values for Temperature Coefficient of Model 240A Output Voltage. The Table shows samples at various settings of the temperature coefficient. Since the internal components determine the instrument's performance, the coefficient differs for each particular instrument.

b. Resistance programing is useful where accurate output voltages are needed in a fixed sequential order. External resistors are added in series with the resistors in the Voltage Dials. This allows remote control of the Model 240A output. In this method, the Model 240A output is set to the minimum operating voltage needed. Besides the external resistors, parts required for this modification are a Cinch-Jones connector and 25 inches of shielded cable.

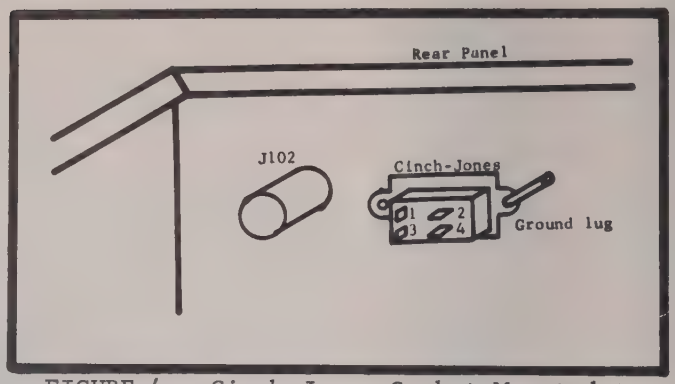


FIGURE 4. Cinch-Jones Socket Mounted to Model 240A. The socket, located in the rear panel, is used for remote programing.

c. Voltage programing is a non-linear high-gain system of output voltage control. It is useful where the Model 240A is to maintain constant some system parameter other than the supply voltage. In this method, the Model 240A Output Voltage Dials are set to the maximum output voltage desired. A positive input voltage to the modified Voltage Supply causes the output voltage to decrease in magnitude. This modification is used only for negative output voltages. Parts required for this modification are a Cinch-Jones connector, 40 inches of cable, a resistor and a diode.

2-14. MODEL 240A MODIFICATIONS FOR RESISTANCE PROGRAMING.

a. Remove the plate over the punched hole on the Model 240A rear panel. This hole accepts a Cinch-Jones 300 series chassis mounting socket (Mfg. No. S-304-AB). Mating plug is a Cinch-Jones plug with cable clamp (Mfg. No. P-304-CCT). Use these connectors or their equivalents. Mount the connector on the rear panel as shown in Figure 4. Use a lug to ground the connector to the Model 240A chassis.

b. Prepare the 18-1/2 inch cable #1 as shown in Figure 5.

1. Use shielded, single conductor cable with insulation which will withstand at least 2000 volts. The conductor should be #25 wire or larger. A satisfactory type is Belden 8411. Overall length for cable #1 is 18-1/2 inches.

2. Cut off 1/4 inch of shield and insulation from end C, leaving bare 1/4 inch of wire. Also, cut off 1 inch of only the outer insulation from end C. Comb out the shield and wrap together. Use 3/4 inch of shrink tubing over the end as shown in Figure 5.

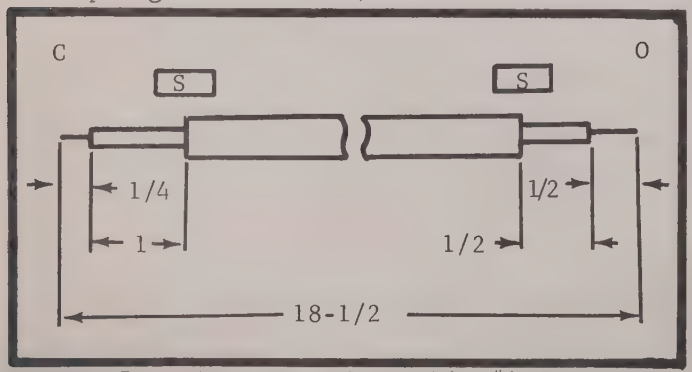


FIGURE 5. Dimensions for Cable #1 for Resistance Programing. Dimensions are in inches.

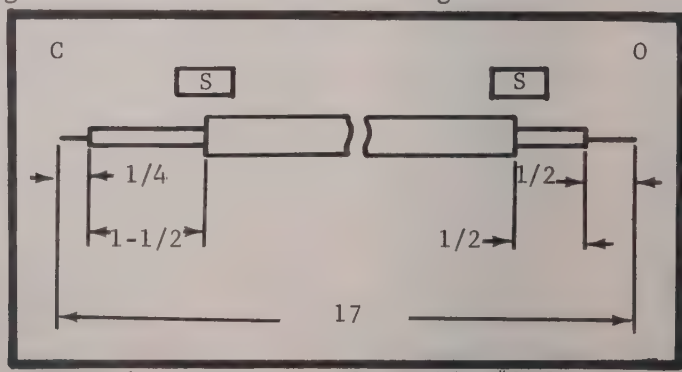


FIGURE 6. Dimensions for Cable #2 for Resistance Programing. Dimensions are in inches.

3. From end O, cut off 1/2 inch of both the outer insulation and the shield. Also, cut off 1/2 inch of only the outer insulation from end O. Put 3/4 inch of shrink tubing over the end as shown in Figure 5.

c. Prepare the 17-inch cable #2 as shown in Figure 6.

1. Use the same type cable as for cable #1. Overall length is 17 inches.

2. Cut off 1/4 inch of shield and insulation from end C, leaving bare 1/4 inch of wire. Also, cut off 1-1/2 inches of only the outer insulation. Comb out the shield and wrap together. Put 3/4 inch of shrink tubing over the end as shown in Figure 6.

3. From end O, cut off 1/2 inch of both the outer insulation and the shield. Also, cut off 1/2 inch of only the outer insulation. Put 3/4 inch of shrink tubing over the end as shown in Figure 6.

d. Connect the cables to the connector.

1. Attach the shields from end C of cables #1 and #2 to pin 3 of the Cinch-Jones connector. Also use a short piece of wire to connect pin 3 to the ground lug.

2. Attach the conductor of cable #1 (end C) to pin 4 of the Cinch-Jones connector.

3. Attach the conductor of cable #2 (end C) to pin 2 of the Cinch-Jones connector.

4. Nothing is attached to pin 1 of the connector.

e. Connect the cables to the Model 240A Voltage Dials.

1. Place both cables along the bottom of the Model 240A along the left side of the cabinet (Figure 15).

2. Remove the violet wire between dot 1 of printed circuit board PC-116 (Figure 20) and terminal 10 of Switch S107 (Figure 15).

3. Connect the conductor of cable #2 (end O) to dot 1 of printed circuit board PC-116.

4. Connect the conductor of cable #1 (end O) to terminal 10 of Switch 107.

2-15. CIRCUIT FOR RESISTANCE PROGRAMING.

a. The accuracy and stability of the external resistors connected in series with the Model 240A sampling resistors will determine the accuracy and stability of the output voltage. These should be similar in specifications to resistors R149 to R179 in the Model 240A: 0.5%, 1/2-watt metal film resistors (Keithley Part No. R61). It is also recommended that the resistors be power derated five to ten times.

b. The programing constant for the external resistors is 1000 ohms per volt. The current remains a constant 1 milliampere. Increasing the output voltage 1 volt requires increasing the external resistance 1 kilohm. For example, to remotely increase the Model 240A output 600 volts requires increasing the external resistance 600 kilohms.

c. In establishing an output sequence, do not go from a high voltage to a voltage near zero. There is a large amount of capacitive energy that must be carried by the remote range switches and damage to switches may result. If it is necessary to switch to zero, consult

paragraph 2-9 on capacitive loads.

d. Make sure the remote range circuit is never at open circuit. This permits the Model 240A output voltage to increase above 1200 volts, which could damage the Voltage Supply. Always use a make-before-break remote switching sequence.

NOTE

Use sufficient insulation because the voltage control is in the negative output voltage side of the Model 240A.

2-16. OPERATION FOR RESISTANCE PROGRAMING.

a. Connect the external resistors between pins 2 and 4 of the Cinch-Jones connector. Use pin 3 as a shield if desired.

b. Set the Model 240A front panel controls to

ON Switch	ON
Voltage Dials	0 0 0
TRIM Control	CAL
OUTPUT Switch	- or +, as desired

c. The minimum output voltage for any setting of the external resistors will be the setting of the Voltage Dials. If zero output is not needed, then set the Voltage Dials to the desired value. All outputs will increase an equal amount. If the Dials are set to 100 volts, all outputs determined with the external resistors will increase 100 volts.

NOTE

Make sure pins 2 and 4 of the Cinch-Jones connector are not left open circuit. The output voltage may rise to approximately 1600 volts; damage may result to the Model 240A or to the load.

d. To return the Model 240A to normal operation, short together pins 2 and 4 of the Cinch-Jones connector.

2-17. MODEL 240A MODIFICATIONS FOR VOLTAGE PROGRAMING.

a. Remove the plate over the punched hole on the Model 240A rear panel. This hole accepts a Cinch-Jones 300 series chassis mounted socket (Mfg. No. S-304-AB). Mating plug is a Cinch-Jones plug with cable clamp (Mfg. No. P-304-CCT). Use these connectors or their equivalents. Mount the connector on the rear panel as shown in Figure 4. Use a lug to ground the connector to the Model 240A chassis.

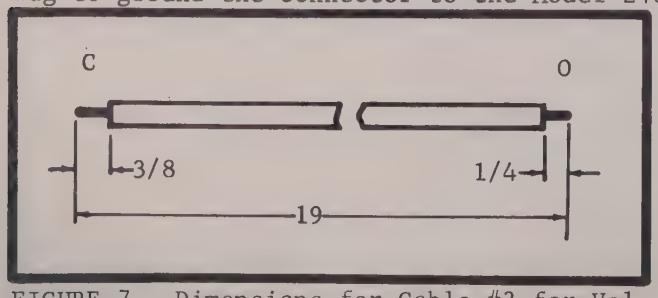


FIGURE 7. Dimensions for Cable #3 for Voltage Programing. Dimensions are in inches.

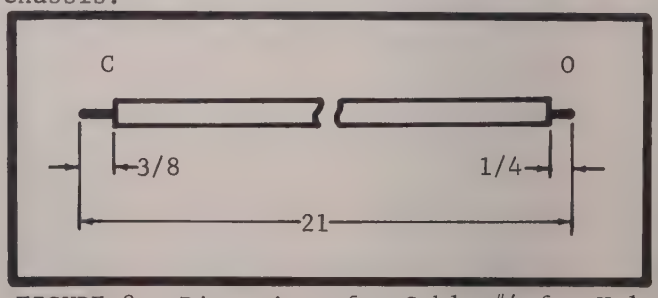


FIGURE 8. Dimensions for Cable #4 for Voltage Programing. Dimensions are in inches.

b. Prepare two cables as shown in Figures 7 and 8.

1. Use unshielded cable with insulation which will withstand at least 2000 volts. The conductor should be #22 or larger. Cable #3 is 19 inches long and cable #4 is 21 inches long.

2. Cut off 3/8 inch of insulation from end C on both cables and 1/4 inch of insulation from end O.

c. Connect the cables to the Cinch-Jones connector.

1. Use a short piece of wire to connect pin 3 to the ground lug at the connector.

2. Attach the conductor of cable #4 (end C) to pin 1 of the Cinch-Jones connector.

3. Attach the conductor of cable #3 (end C) to pin 2 of the Cinch-Jones connector.

Control Voltage, volts	Output Voltage, volts
0	-1000
+4.27	-900
+4.52	-800
+4.62	-700
+4.67	-600
+4.70	-500
+4.72	-400
+4.74	-300
+4.78	-200
+4.80	-100

TABLE 2. Typical Programing Coefficient for Voltage Programing. The Model 240A is set for -1000 volts; the load is a 200-kilohm resistive load: The value of R_S (Figure 9) is 900 ohms. Changing the circuit will change the coefficient.

d. Connect the cables to the Model 240A printed circuit boards.

1. Connect cable #4 (end O) to printed circuit board PC-117 at the tape of the base of transistor Q105 (Figure 15.)

2. Connect cable #3 (end O) to printed circuit board PC-117 next to dot 14 (Figure 15).

2-18. CIRCUIT FOR VOLTAGE PROGRAMING.

a. Since each particular supply will be different, no definite values may be given for system operation or stability. These must be checked for the particular application.

b. The Model 240A Voltage Dial setting determines the maximum output voltage. The remote control voltage reduces the output voltage below this maximum value. This protects the Model 240A and loads whose voltage rating may not be exceeded.

c. The load current drawn and the remote control voltage determine the lower voltage range. Attempting to use outputs less than 100 volts results in large non-linearities. It is recommended that at least 0.5-milliampere load current be present at 100 volts, requiring at least 5-milliampere load current at 1000 volts.

d. The circuit for voltage programing includes a 900-ohm resistor, R_S. between the external control voltage and the Model 240A (see Figure 9). The value of R_S may be reduced below 900 ohms, but if the external control voltage becomes too large the Model 240A may be damaged.

e. Since the Model 240A is operating in a condition which is somewhat analogous to an open loop, there is high gain from the control terminals to the output terminals. The programing coefficient will vary; Table 2 presents a typical example. The coefficient

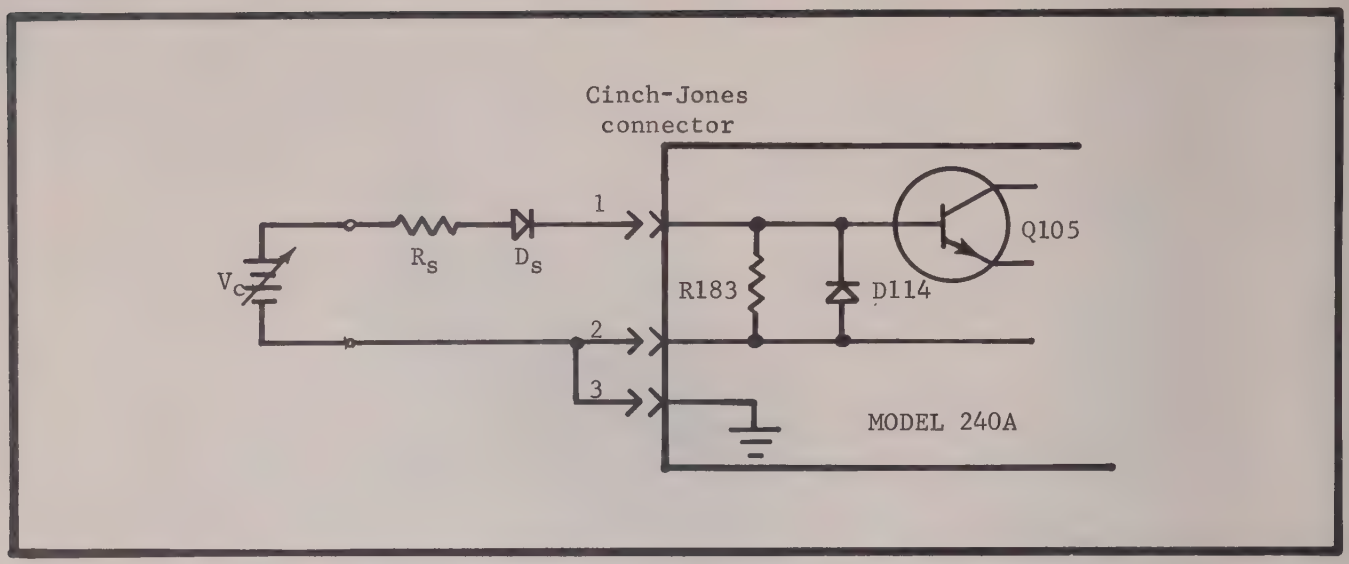


FIGURE 9. Circuit for Voltage Programing. The external control voltage, V_C, is connected to the Cinch-Jones connector through a 900-ohm resistor, R_S, and diode D_S. Cables 3 and 4 connect the external voltage to the printed circuit board within the Model 240A.

for any circuit must be determined for the particular application.

f. If the control voltage is a step function, the ranging speed is a function of resistive and capacitive loading, and it is approximately exponential. In the example shown in Table 2 and with no external capacity, the time constant (0 to 63%) is approximately 15 milliseconds.

2-19. OPERATION FOR VOLTAGE PROGRAMING.

a. Short together pins 2 and 3 on the Cinch-Jones mating connector. Connect a diode and resistor to pin 1 as shown in Figure 9. Normally, use a 900-ohm, 1/2-watt resistor. The diode (1N645) prevents the Model 240A output voltage from exceeding the dialed supply voltage if the external control voltage becomes negative.

b. Set the Model 240A front panel controls to

ON Switch	ON
Voltage Dials	Desired Output
TRIM Control	CAL
OUTPUT Switch	-

If the OUTPUT Switch is set to either OFF or +, the Voltage Supply will be shorted. Therefore, either OFF or + are standby positions, and the OVERLOAD Lamp will light. In - output, the OVERLOAD Lamp functions normally.

c. To return the Model 240A to normal operation, disconnect the jack from the rear of the instrument.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Keithley Model 240A High Voltage Supply furnishes outputs from 0 to 1200 volts dc. The block diagram (Figure 10) shows the relationship between operating circuits. Setting the sampling resistors in the voltage divider selects the output voltage. Any difference between the voltage drop across a string of calibrating resistors and the zener reference is sensed by the voltage control comparator and amplified. The amplified difference signal is returned to the series regulator. This maintains the output voltage at a constant level determined by the divider ratio selected with the front panel Voltage Dials. The current limit comparator and amplifier prevents the output current from exceeding 12.5 milliamperes.

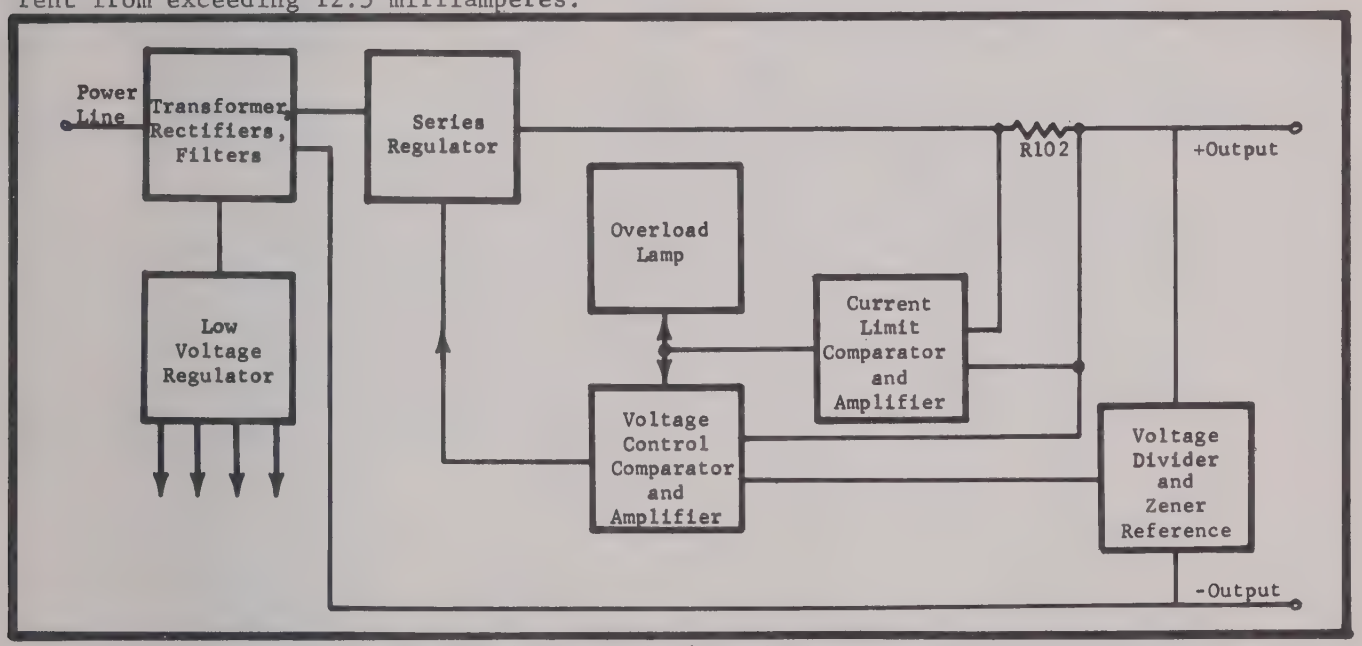


FIGURE 10. Model 240A Block Diagram

NOTE

Refer to Schematic Diagram 19197D for circuit designations.

3-2. HIGH AND LOW VOLTAGE SUPPLIES.

a. High voltage for the series regulator tube is obtained using a voltage doubler circuit, composed of diodes D110 and D111 and filter capacitors C104 through C109. This circuit increases transformer life and reduces corona. Resistors R137 through R142 equalize the voltage across the filter capacitors.

b. Low voltage for the control circuitry is obtained from rectifiers D112 and D113 and filter capacitors C111 and C112. Cascaded regulators V102, V103 and D101, D106 regulate this voltage.

3-3. VOLTAGE CONTROL. The voltage divider consists primarily of zener reference D105, the sampling voltage divider, R149 to R179, and the calibrating resistor divider, R117 to R121. See Figure 11.

a. The front panel Voltage Dials, S104 to S106, set the value of the sampling resistors. Changing the sampling resistors, R149 through R179, varies the output voltage. The output voltage, E_o (Figure 11), assumes a value such that the voltage drop across the calibrating resistors, R117 to R121, is equal to the voltage of the zener reference, D105. The voltage control comparator and amplifier sense any difference between these voltages and correct the voltage, E_i, through the series regulator, V101.

b. The voltage control comparator and amplifier consist of a differential amplifier (transistors Q105 and Q106), current amplifiers (transistors Q103 and Q104), and a voltage amplifier (transistors Q101 and Q102). Its output controls the grid voltage of the series regulator tube, V101. Diodes D103, D104, D108, D109 and D114 and resistors R116 and R183 protect the voltage control comparator and the zener reference from switching transients when the output voltage is changed. Diode D102 prevents a reverse bias on the current amplifier Q104 beyond its breakdown voltage.

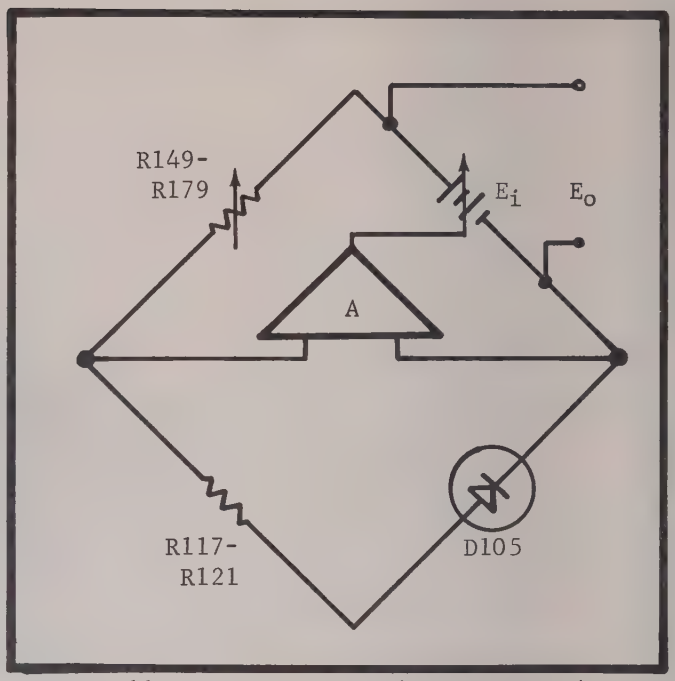


FIGURE 11. Diagram of Voltage Control Comparator. R149 to R179 are the sampling resistors set with S104 to S106. R117 to R121 are the calibrating resistors. E_i is the voltage through the series regulator, V101. E_o is the Model 240A output voltage. A is the voltage control comparator and amplifier.

3-4. OUTPUT VOLTAGE. When the OUTPUT Switch, S107, is set to either + or -, it grounds one side of the Voltage Supply and connects the other side to the parallel Output Connectors, J101 and J102. Setting the Switch to OFF grounds the negative terminal of the Voltage Supply. The positive terminal is left disconnected, and resistor R180 shunts the Output Connectors to ground.

3-5. CURRENT CONTROL.

a. The output current is sensed by measuring the voltage drop across resistor R102. A current limit comparator and differential amplifier, transistors Q107 and Q108, compares this voltage to that at the tap of potentiometer R126.

b. The comparator controls the OVERLOAD Lamp, DS102, and the Voltage Supply operating mode: normal, when there is no overload on the Model 240A; and current limited, when the output current exceeds 10 milliamperes. Selection between modes occurs automatically using a switch composed of diode D107 and the base-emitter of transistor Q104. In the normal mode, the voltage on the anode of diode D107 is less than the voltage on the base of Q104. Therefore, Q104 conducts and D107 does not. In the current limit mode, the voltage on the anode of D107 is higher than that on the base of Q104. D107 conducts and Q104 does not.

c. The neon OVERLOAD Lamp, DS102, is switched on by transistor Q110 turning off. As the lamp begins to ignite, Q110 is turned off hard, causing the lamp to come on to full brilliance. Base current for transistor Q110 is supplied by transistor Q109.

SECTION 4. SERVICING

4-1. GENERAL. This Section contains the maintenance and troubleshooting procedures for the Model 240A Voltage Supply. Follow these as closely as possible to maintain the specifications of the instrument.

4-2. SERVICING SCHEDULE. The Model 240A needs no periodic maintenance beyond the normal care required of high-quality electronic equipment. Occasional checks of the output, described in Section 5, will show the need of any adjustments. No part should need frequent replacement under ordinary use.

4-3. PARTS REPLACEMENT.

a. The Replaceable Parts List in Section 7 describes the electrical components of the Voltage Supply. Replace components only as necessary. Use only reliable replacements which meet the specifications.

b. The zener diode, D105, is selected as are diodes D108 and D109; transistors Q105 and Q106 are a matched pair. Order these replacements only from Keithley Instruments, Inc., or its representative, as well as other parts marked for Keithley manufacture (80164) in the Replaceable Parts List.

Instrument	Use
Ballantine Model 320A Wideband, True RMS VTVM, 100 microvolts to 330 volts, 5 cps to 4 Mc	Check output noise
Keithley Instruments Model 153 Microvolt-Ammeter, 10 microvolts to 1000 volts, ±1% at 3 millivolts; 200-megohm input resistance, 10^{-11} to 0.1 ampere	Circuit checking
Keithley Instruments Model 610B Electrometer, 10^{-3} to 100 volts, 10^{-14} to 0.3 ampere, 10^{2} to 10^{14} ohms; 10^{14} ohm input resistance	Circuit checking
Keithley Instruments Model 660A Differential Voltmeter, ±0.02% limit of error, 100 microvolts to 500 volts	Calibrating output voltage
Keithley Instruments Model 6601A 100:1 Divider, ±0.01% accuracy	Used with Model 660A above 500 volts
Tektronix Model 504 Oscilloscope	Check output noise

TABLE 3. Equipment Recommended for Model 240A Troubleshooting and Calibration. Use these instruments or their equivalents.

Trouble	Probable Cause	Remedy
No output voltage, pilot light off	Line cord not plugged in	Plug in line cord
	117-234 Switch not correctly set	Set Switch correctly
	ON Switch off	Set to ON
	Fuse F101 Blown	Replace fuse; if fuse repeatedly blows, check further
No output voltage, repeated fuse failure	V101, V102, V103 or associated circuitry faulty	See paragraph 4-6
No output voltage but pilot light on	Trouble in high or low power supplies or tube filaments	See paragraph 4-6
	Faulty V101	Check, replace if faulty
	Current limiting or voltage control amplifiers defective	See paragraphs 4-7 and 4-8
Output voltage not correct by an approximately constant amount	Zero potentiometer not set	See paragraph 5-3
	Voltage control amplifier will not zero	See paragraphs 4-7 and 4-8
	Output noise high	See paragraph 4-10
Output voltage not correct by an approximately constant percentage of Voltage Dial setting	CAL potentiometer not set	See paragraph 5-4
	Diodes D103, D104, D108 or D109 leaking	Check, replace if faulty
	Faulty Q106	Check, replace if faulty
	Zener D105 or R117, R118, R119, R120 or R121 faulty	Check, replace if faulty
Output voltage not correct for low voltage outputs only	Low grid voltage on V101	Check, replace if faulty
	Amplifier not balanced	See paragraphs 4-7 and 4-8
	Output noise high	See paragraph 4-10
Output voltage not correct at only a few dial settings	Switches S104, S105 or S106 or one of resistors R149 to R179 faulty	Return to factory for repair

TABLE 4. (Sheet 1). Model 240A Troubleshooting. Read paragraph 4-5 before performing any repairs.

Trouble	Probable Cause	Remedy
Output not correct at high voltage outputs only	High voltage transformer, rectifiers or filters faulty	See paragraph 4-6
	C113 or C114 leaking	Check, replace if faulty
	V101 screen circuit open or tube faulty	Check, replace if faulty
	Amplifier swing not sufficient	See paragraphs 4-7 and 4-8

TABLE 4. (Sheet 2). Model 240A Troubleshooting. Read paragraph 4-5 before performing any repairs.

4-4. TROUBLESHOOTING.

a. The procedures which follow give instructions for repairing troubles which might occur in the Model 240A. Use the procedures outlined and use only specified replacement parts. Table 3 lists equipment recommended for troubleshooting. If the trouble cannot be located or repaired, contact Keithley Instruments, Inc., or its representative.

b. Table 4 lists problems which might occur. If the repair indicated does not work, check through each circuit as described in the following paragraphs. Refer to the description in Section 3 to understand the circuits. The complete circuit diagram, 19197D, is in Section 7.

NOTE

Use extreme caution when working within the Model 240A. High voltages are present at many points. Before removing the cover, make sure the power cord is disconnected. After removing the cover, discharge all metal-cased capacitors before proceeding with repairs. Discharge all high voltages through a bleeder.

4-5. PROCEDURES TO GUIDE TROUBLESHOOTING.

a. Always set the OUTPUT Switch to - when working on the Model 240A. This keeps the voltage control amplifier ground at case potential. When the Switch is at + or OFF, the series regulator low is above case ground by the amount of the output voltage.

b. Before troubleshooting the Voltage Supply, check the external circuits. Check the fuse, power cord and power source.

c. The schematic diagram 19197D contains the voltages at selected points. These were measured with the Model 153 to ±15%, and with the Model 240A controls set:

ON Switch	ON
Voltage Dials	0 0 0
TRIM Control	CAL
OUTPUT Switch	-

d. Check the vacuum tube, V101, and the gas tubes, V102 and V103. Check tubes by replacing them. Normally, replacing tubes will clear up any difficulty.

4-6. TRANSFORMER CHECK. If no output voltage appears and if the fuse repeatedly blows, follow these procedures.

a. Removing tube V101 (Figure 14) from the socket unloads the high voltage and filament winding of the transformer.

b. Removing tubes V102 and V103 (Figure 16) from their sockets unloads the low voltage winding of the transformer.

c. If the fuse continues to blow, the trouble is in the rectifiers, filters, transformers or wiring. The best approach is to disconnect all secondary leads and check the transformer using the Model 610B as an ohmmeter.

4-7 TROUBLESHOOTING THE VOLTAGE CONTROL AMPLIFIER.

a. To troubleshoot the voltage control amplifier, first remove the high voltage. Turn the ON Switch off. Remove tube V101 (Figure 14) from its socket and disconnect the plate cap. Make sure the plate cap is clear of all surrounding components. Place a shorting jumper across either diode D108 or D109 (Figure 18).

b. Set the front panel controls to

ON Switch	ON
Voltage Dials	0 0 0
TRIM Control	CAL
OUTPUT Switch	-

Do not connect anything to the Output Receptacles.

c. Connect the Model 153 between pin 5 of tube V101 and ground. Turn the Model 240A on. Adjust the ZERO potentiometer R114 (Figure 19). Turning the potentiometer should swing the voltage from approximately 0 to -36 volts. Set the potentiometer for -20 volts.

d. If the -20 volts can be set, then the voltage control amplifier will balance at dc and it is probably functioning properly. If the -20 volts can not be set, the trouble may be in either the voltage control amplifier or in the current limit circuit. See paragraph 4-8.

4-8. TROUBLESHOOTING THE CURRENT LIMIT CIRCUITS.

a. A defective current limit circuit can interfere with the voltage control amplifier. First, see if the voltage control amplifier is operating correctly (paragraph 4-7).

b. Set the front panel controls as in paragraph 4-7, b. Since there is no overload, there should be a reverse voltage across diode D107 (Figure 18). The amplifier should be in its normal mode.

c. If there is not a reverse voltage across D107, disconnect the current limit circuit by disconnecting one end of diode D107. If the voltage control amplifier does not yet balance, the trouble is in the amplifier. If the voltage control amplifier balances,

Zener Supply Voltage (Pt. A)	Point B	Point C	Point D
-44 volts	-0.42 volt	-0.30 volt	+0.24 volt
-40 volts	-0.03 volt	-0.10 volt	+0.63 volt
-36 volts	+0.61 volt	+0.82 volt	-1.25 volts

TABLE 5. Current Limit Circuit Voltages. These values were measured with the Model 153 to ±15%. The Voltage Dials are set to 000 and the OUTPUT Switch to -. The range from -36 to -44 volts is the limits of the voltages across the zener diode D106. The points B, C and D are indicated in Figure 12.

the trouble is in the current limit circuit. Locate the trouble by making voltage measurements within these circuits.

4-9. TROUBLESHOOTING THE OVERLOAD LAMP CIRCUIT.

a. Trouble in the OVERLOAD Lamp driver circuit is indicated by the lamp not lighting when the voltage control amplifier and the current limit circuit are working. The latter circuit is working if output noise increases as the overload increases and current limiting action occurs.

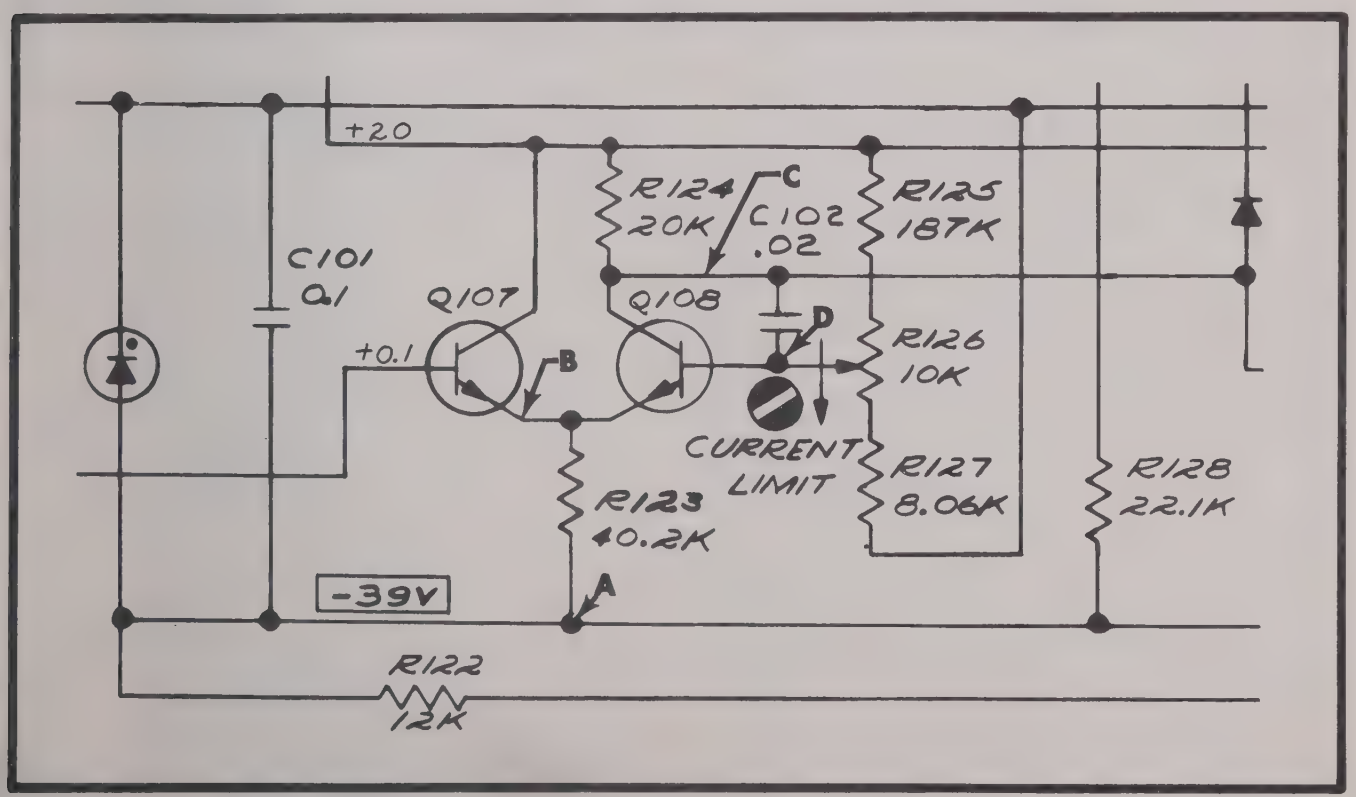


Figure 12. Voltage Points within Current Limit Circuit. Refer to Table 5 for values which depend upon the voltage at Point A.

b. In overload condition, the voltage between the emitter and collector of transistor Q110 (Figure 18) should be more than -105 volts. If it is and the lamp will not light, then the lamp is defective.

c. If -105 volts is not present, then either transistor Q109 or Q110 (Figure 18) or the associated circuitry is defective. Measure the voltages within the circuits to locate the trouble.

d. Voltages within the current limit amplifier vary considerably, depending upon the voltage across zener diode D106. Nominally, the voltage is -39 volts. Table 5 gives the correct values for points in Figure 12 for voltages within the limits of the zener if the instrument is working properly.

4-10. OUTPUT NOISE. With a voltage setting of less than 600 volts, the output noise on the Model 240A may be read by connecting the Model 504 oscilloscope or the Model 320A voltmeter across the output terminals of the Model 240A. With a voltage setting greater than 600 volts, use a blocking capacitor box (Figure 13) with the oscilloscope or voltmeter. When using the box keep the switch on the box closed except when reading noise. Excessive power line noise will tend to increase the output noise. The output noise should be less than 10 millivolts peak-to-peak or 1.0 millivolt rms. If the noise is higher, then most likely one of the regulator tubes V102 or V103 is defective. If replacing these tubes does not clear up the trouble, then either the pass tube, V101, is defective or one or more of the amplifier transistors, Q101 through Q106, is defective.

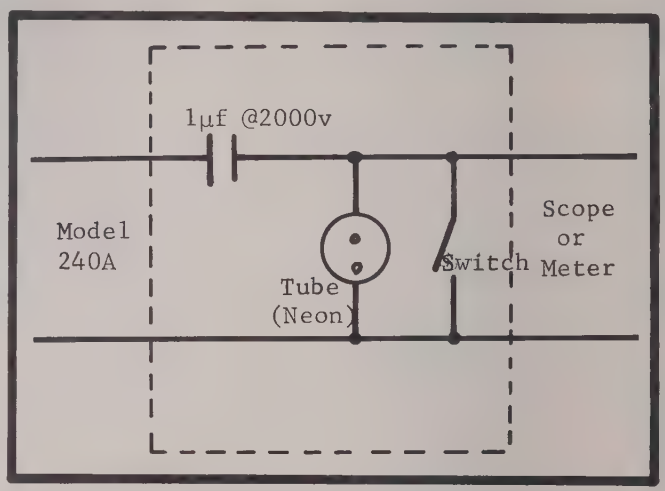


FIGURE 13. Blocking Capacitor Box Used With an Oscilloscope or Voltmeter to Read Output Noise on Model 240A.

SECTION 5. CALIBRATION

5-1. GENERAL.

a. The following procedures are recommended for calibrating the Model 240A. It is also recommended that the equipment listed in Table 3 be used. If difficulty is encountered, contact Keithley Instruments, Inc., or its representative.

b. Before performing any calibration, make sure the Model 240A is in working order. Allow it to stabilize for at least 30 minutes with both covers on.

c. If the instrument is not within specifications after the calibration, follow the troubleshooting procedures or contact Keithley Instruments, Inc., or its representatives.

5-2. CALIBRATION SCHEDULE. Check the accuracy of the output voltage (paragraph 5-4) every six months and recalibrate as necessary. Also, recalibrate the instrument if the series regulator tube, V101, or the zener diode, D105, is replaced.

5-3. ZERO BALANCE ADJUSTMENT.

a. This adjustment sets the Model 240A for no output when the Voltage Dials are set to 0 0 0.

b. Set the front panel controls to

ON Switch	ON
Voltage Dials	0 0 0
TRIM Control	CAL
OUTPUT Switch	-

Connect the Model 153 to the Model 240A OUTPUT Receptacle and set it initially to its 10-millivolt range. Adjust the ZERO potentiometer, R114 (Figure 19), for zero output ±1 millivolt.

5-4. VOLTAGE CALIBRATION.

a. Connect the Model 660A to the Model 240A OUTPUT Receptacle. Allow the Voltage Supply to warm up for at least 30 minutes. Set the front panel controls to

ON Switch	ON
Voltage Dials	any output above 10 volts
TRIM Control	CAL
OUTPUT Switch	-

b. The Model 660A should read the Model 240A output to ±0.5%. If necessary, adjust the output using the CAL potentiometer R117 (Figure 19). If the potentiometer does not have sufficient range, add or remove jumpers across resistors R119, R120 and R121 (see schematic diagram 19197D).

Control	Circuit Desig.	Fig. Ref.	Refer to Paragraph
Zero Adjustment	R114	19	5-3
Calibration Adjustment	R117	19	5-4
Current Limit Adjustment	R126	19	5-5

TABLE 6. Model 240A Internal Controls. The Table lists all internal controls, the figure picturing the location and the paragraph describing the adjustment.

c. For a quick check, measure the output voltage at several different settings. Adjust the CAL potentiometer R117 (Figure 19) for minimum percentage deviation from the dial setting.

d. For best accuracy, check each ranging resistor and then adjust the CAL potentiometer for minimum deviation from the dial setting. Check the resistor by measuring the output voltage at each dial setting for each Voltage Dial. Keep two Dials set to zero and measure the output for each position of the third dial. Output should be within ±0.5% of the setting.

5-5. CURRENT LIMIT CIRCUIT ADJUSTMENT.

a. This adjustment sets the Model 240A current limit circuit for maximum current output. The factory adjustment is for a short circuit current of 12.5 milliamperes, although the adjustment range is from 6 to 16 milliamperes. This range provides a useful output current from about 4 to 14 milliamperes. At outputs above 10 milliamperes, however, some specifications may be degraded. (See paragraph 2-7).

b. Connect the Model 153 to the Model 240A OUTPUT Receptacle. (If an equivalent Ammeter is used, its input drop must be less than 150 millivolts.) Initially, set the Model 153 sensitivity to 30 milliamperes full scale. Set the Model 240A controls to

ON Switch	ON
Voltage Dials	1 0 0
TRIM Control	CAL
OUTPUT Switch	-

Adjust the CURRENT LIMIT potentiometer R126 (Figure 19) until the output current is 12.5 milliamperes ±0.2 milliampere.

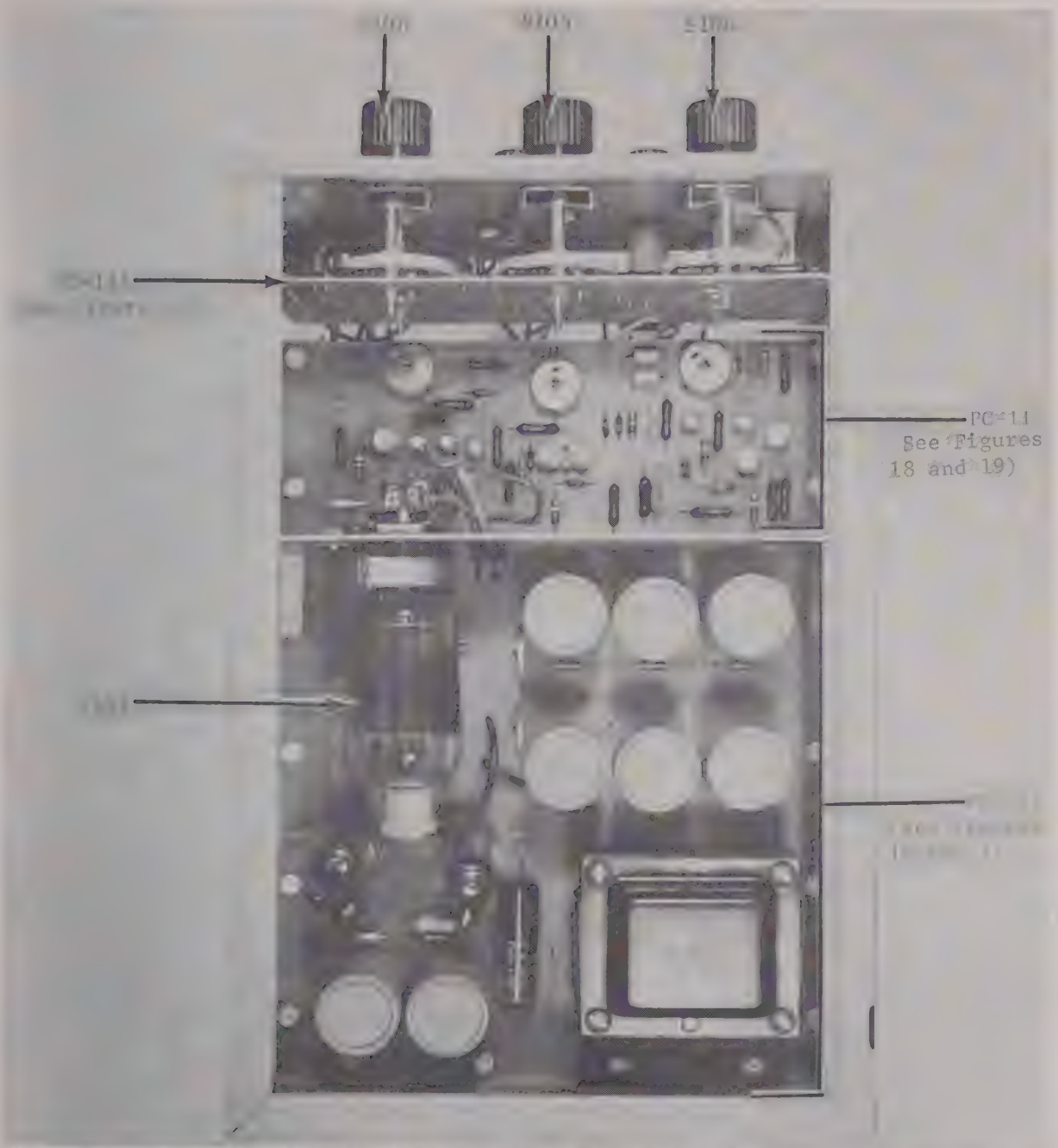


FIGURE 14. Top View of Model 240A Chassis. Locations of components, switches and printed circuits are shown. Refer to Parts List and schematic diagram for circuit designations.

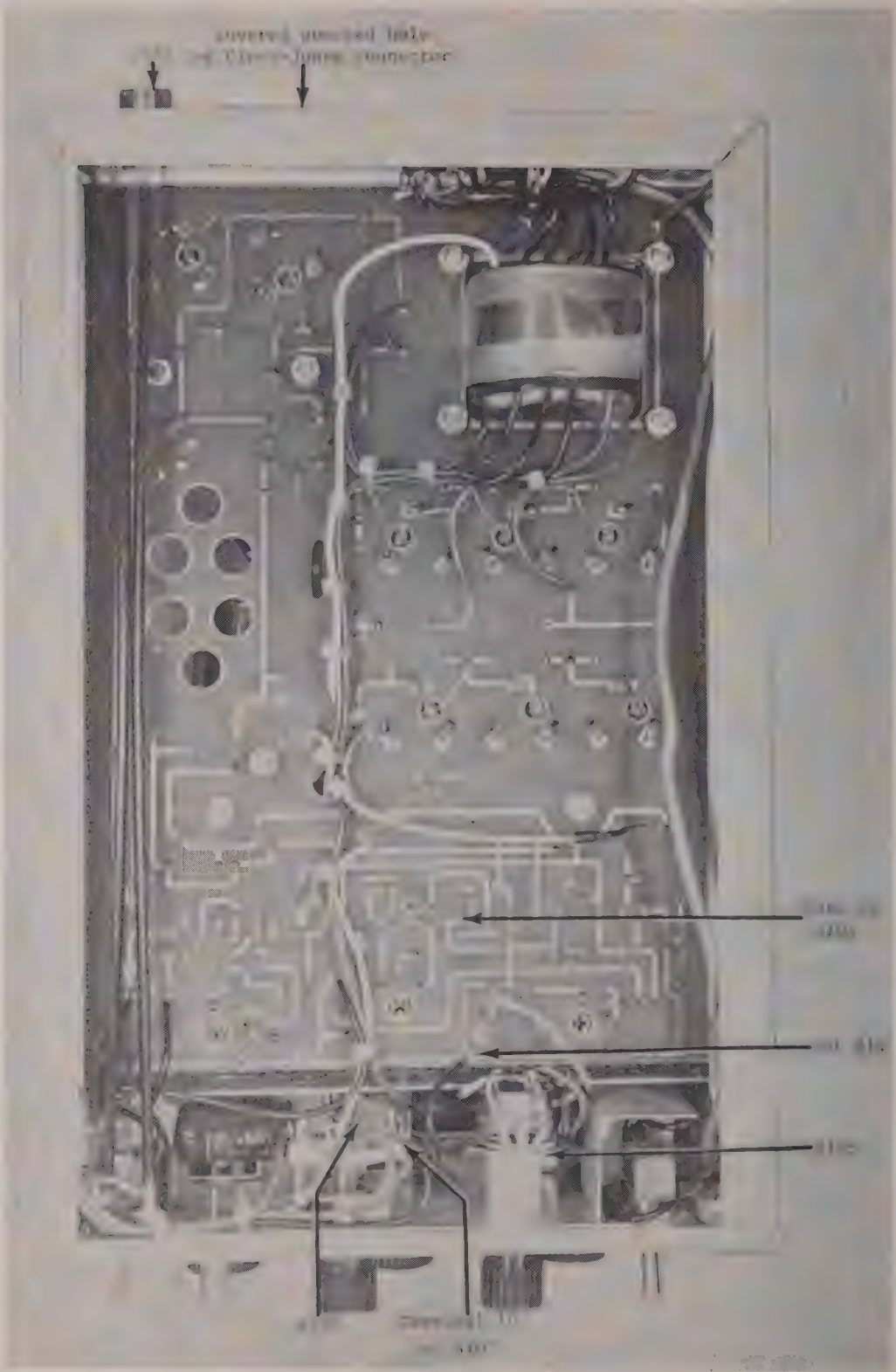


FIGURE 15. Bottom View of Model 240A. Locations of components and test points are shown. Refer to Parts List and schematic diagram for circuit designations. The two cables shown between the Input and Output Receptacles are not cables for programming.

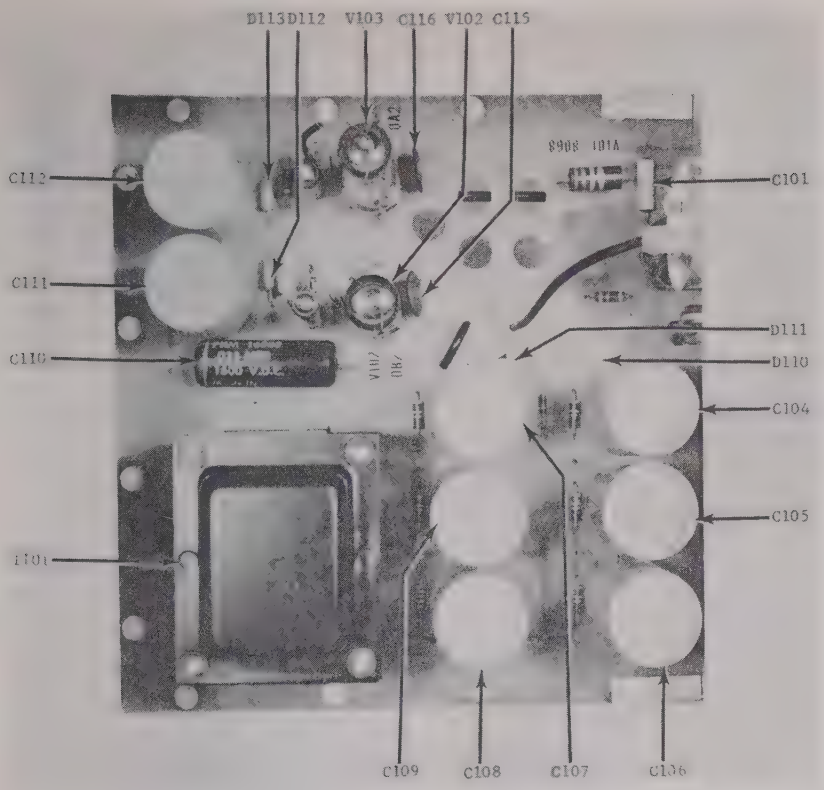


FIGURE 16. Capacitor, Diode, Transformer and Tube Locations on Rear Section of Printed Circuit Board PC-117. For resistor locations see Figure 17.

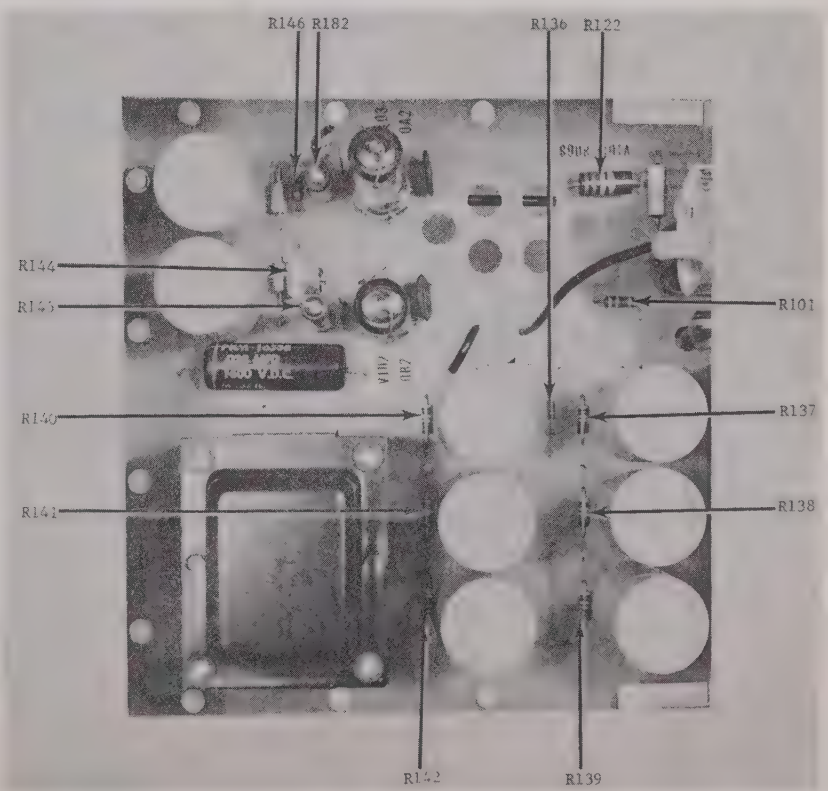


FIGURE 17. Resistor Locations on Rear Section of Printed Circuit Board PC-117. For other component locations see Figure 16.

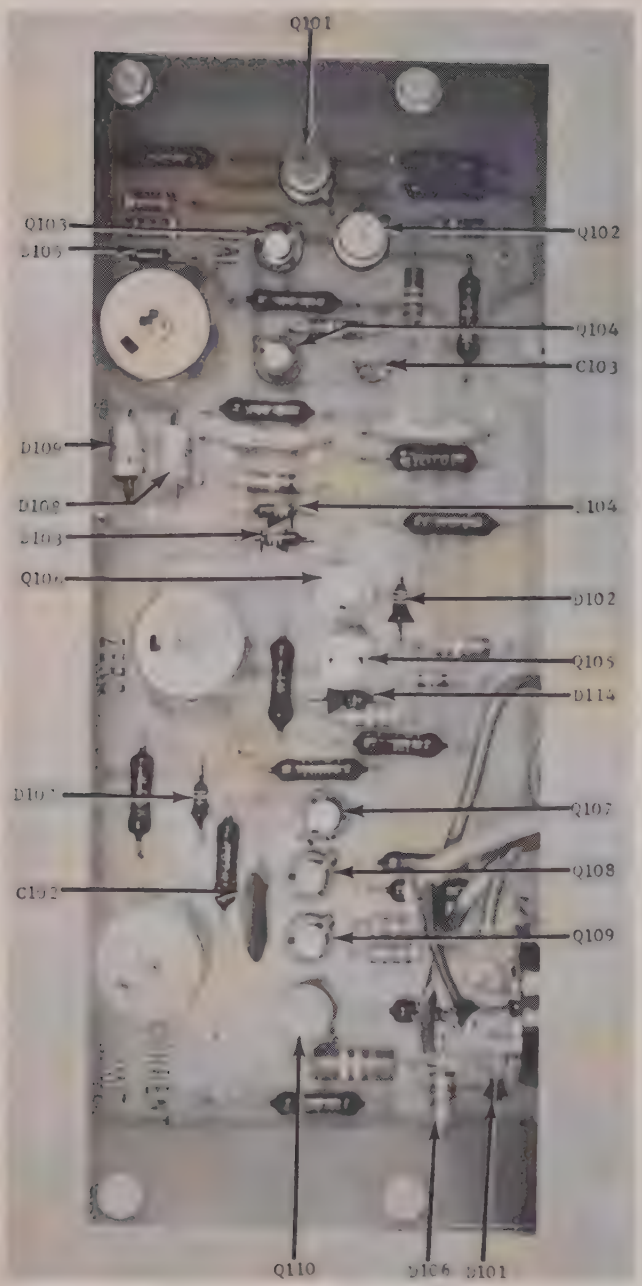


FIGURE 18. Capacitor, Diode and Transistor Locations on Front Section of Printed Circuit Board PC-117. For resistor locations see Figure 19.

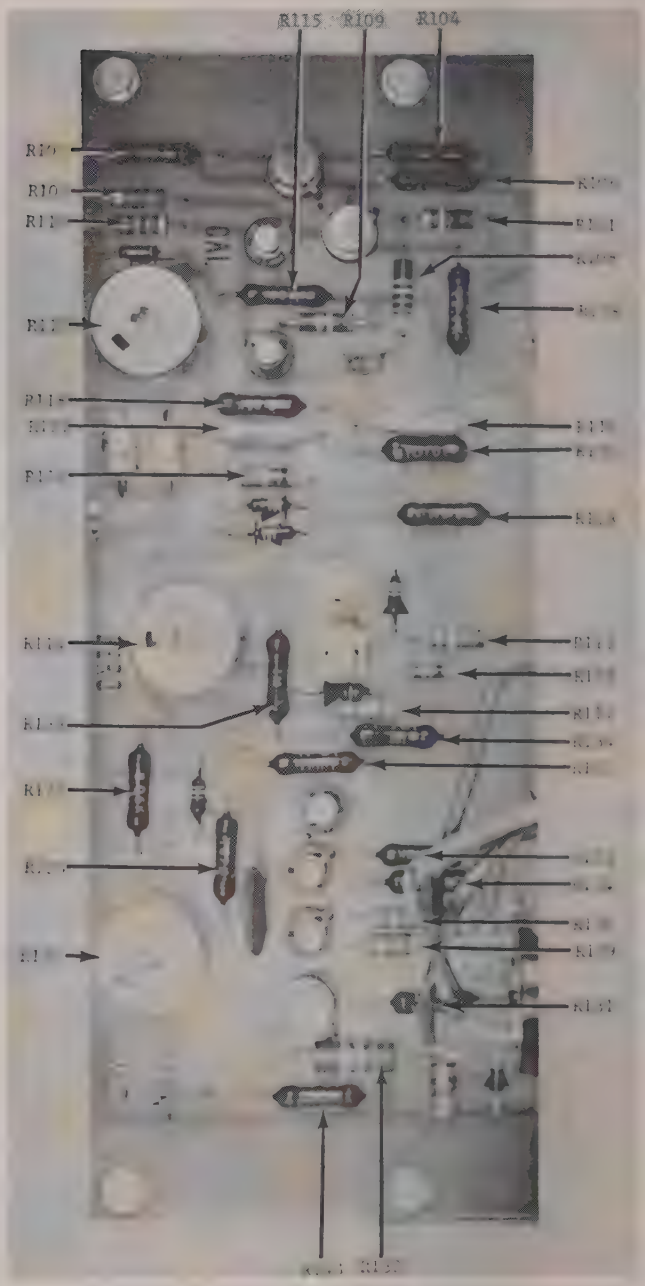


FIGURE 19. Resistor Locations on Front Section of Printed Circuit Board PC-117. For other component locations see Figure 18.

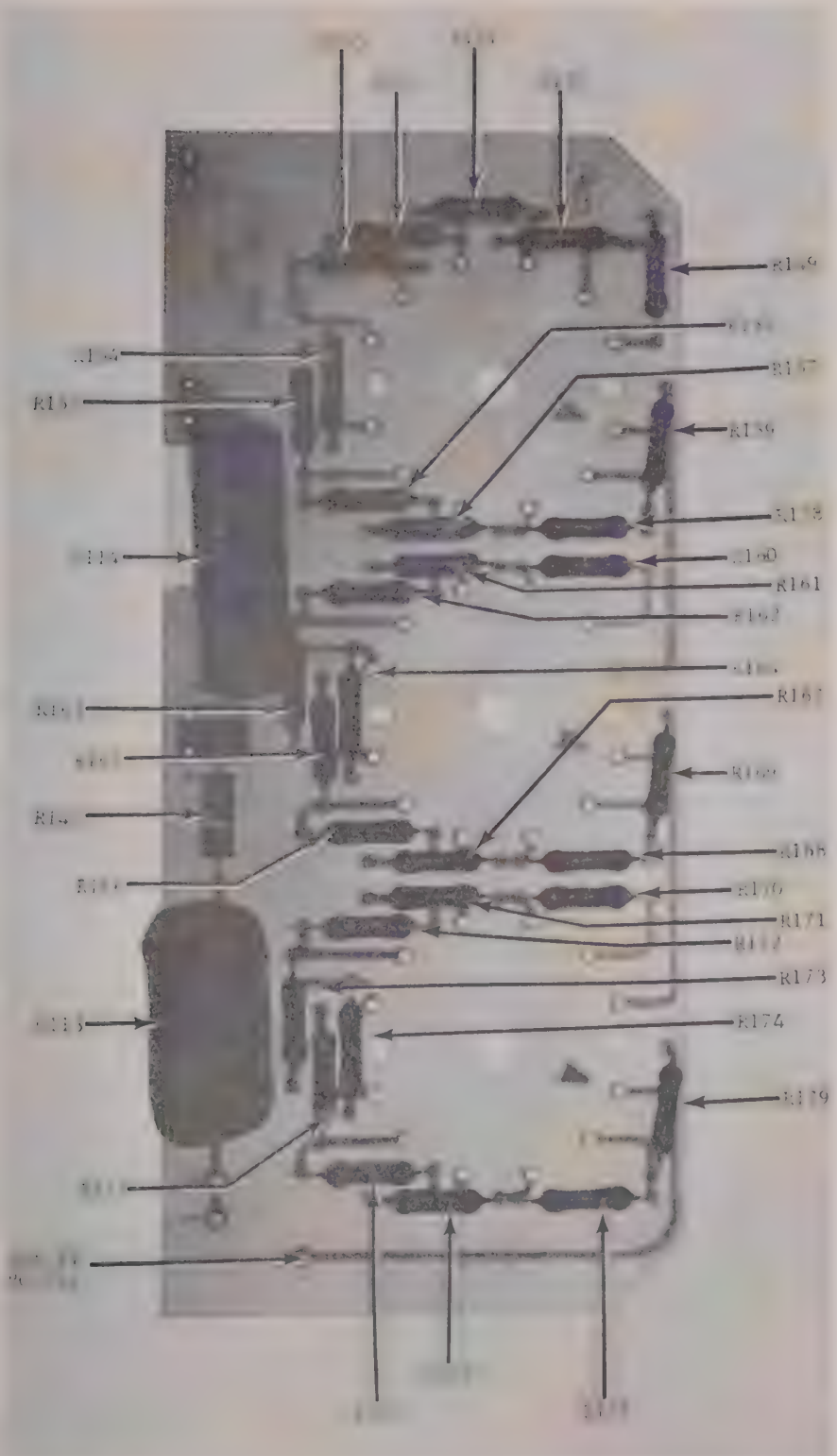


FIGURE 20. Component Locations on Printed Circuit Board PC-116.

SECTION 6. ACCESSORIES

6-1. MODEL 4003A RACK MOUNTING KIT.

a. The Model 4003A converts the Model 240A from a bench model to rack mounting. Rack dimensions are 5-1/4 inches high x 19 inches wide x 13 inches deep. The Supply converts to half-rack size, and the Kit contains a half-rack adapter panel. Kit accommodates any Keithley 5-1/4 inch high half-rack instrument, whether 10 or 13 inches long.

b. Procedure. Remove the wrap-around cover on the Supply by removing the two corner screws at the bottom of each side. Add the rack mounting parts to the Supply as shown in Figure 21. Attach in this order: cover (1), rack angle (4), panel support angle (2), rack adapter panel (5), and chassis connecting plate (3).

Item (See Fig. 21)	Description	Keithley Part No.	Quantity
1	Cover Assembly (10-inch long models)	18554B	1
---	Cover Assembly (13-inch long models)	20015B	1
2	Panel Support Angle	17476A	1
3	Chassis Connecting Plate	19126A	1
4	Rack Angle	14624B	1
5	Rack Adapter Panel	17452B	1
6	Screw, slotted, #10 x 1/2	---	4
7	Screw, round head, hex socket, #10 x 1/2	---	4

TABLE 7. Parts List for Model 4003A Rack Mounting Kit.

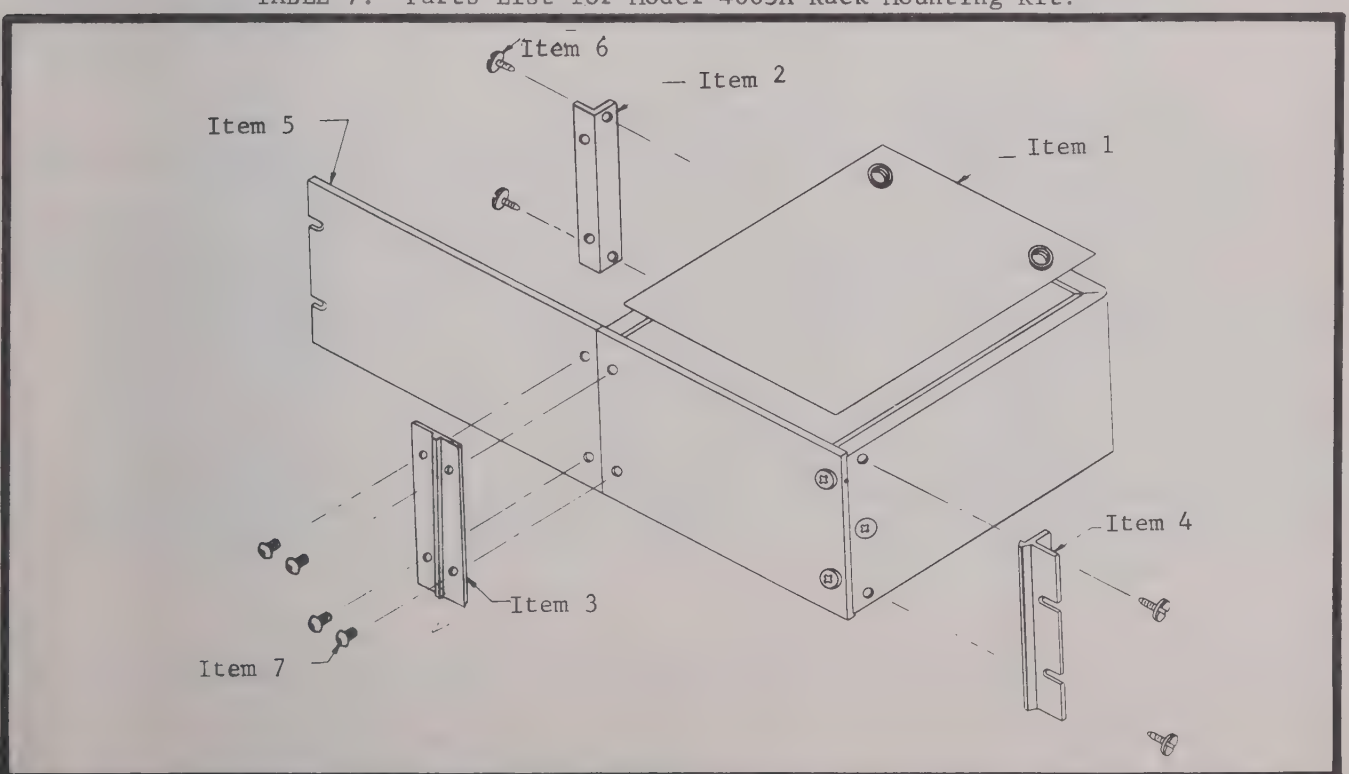


FIGURE 21. Exploded View of Model 4003A Rack Mounting Kit. Refer to Table 7 for parts list.

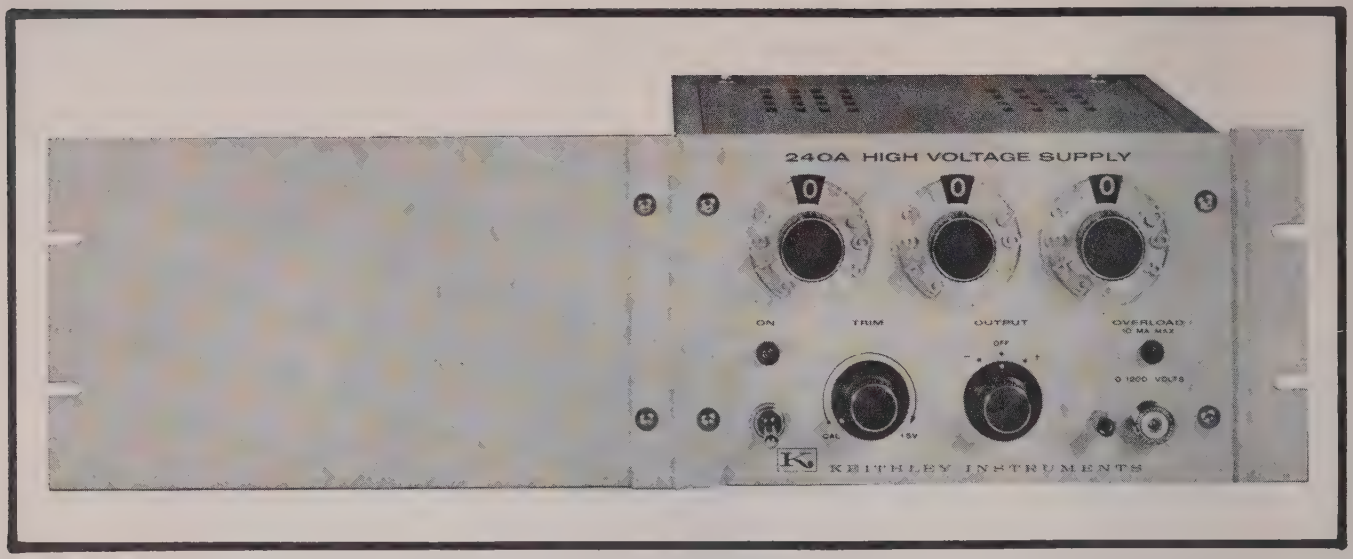


FIGURE 22. Model 240A Converted for Rack Mounting with Model 4003A Rack Mounting Kit.

6-2. MODEL 4004A DUAL RACK MOUNTING KIT.

a. The Model 4004A Kit converts the Model 240A to rack mounting. The assembled Kit will contain either two Model 240A's or any other combination of 2 Keithley 5-1/4 inches high half-rack instruments. Dimensions are 5-1/4 inches high x 19 inches wide.

b. Procedure. Remove the wrap-around cover on each Supply by removing the two corner screws at the bottom of each side. Assemble the rack mounting parts as shown in Figure 23. Attach in this order: covers (1), two rack angles (5), chassis connecting plate (2) or zee bracket (3), and chassis connecting plate (4). If the two instruments are both 10 inches or 13 inches long, use the chassis connecting plate. If one instrument is 10 inches long and the other is 13 inches, use the zee bracket.

Item (See Fig. 23)	Description	Keithley Part No.	Quantity
1	Cover Assembly (10-inch long models)	18554B	1
---	Cover Assembly (13-inch long models)	20015B	1
2	Chassis Connecting Plate	19126A	1
3	Zee Bracket	19144A	1
4	Chassis Connecting Plate	17454A	1
5	Rack Angle	14624B	2
6	Screw, slotted, #10 x 1/2	---	8
7	Screw, round head, hex socket, #10 x 1/2	---	4

TABLE 8. Parts List for Model 4004A Dual Rack Mounting Kit. Use either item 2 or 3, depending upon instrument length.

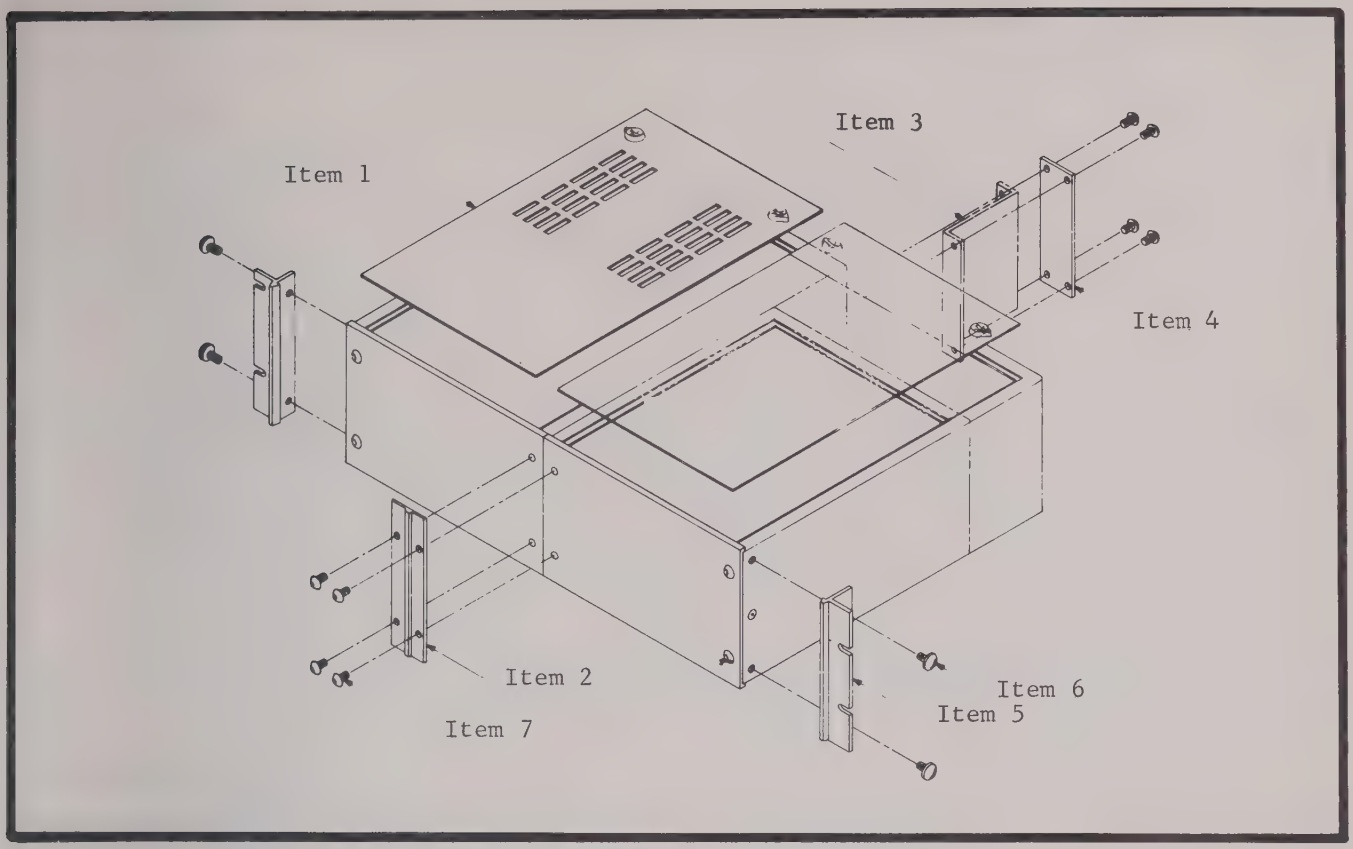


FIGURE 23. Exploded View of Model 4004A Rack Mounting Kit. Refer to Table 8 for parts list.

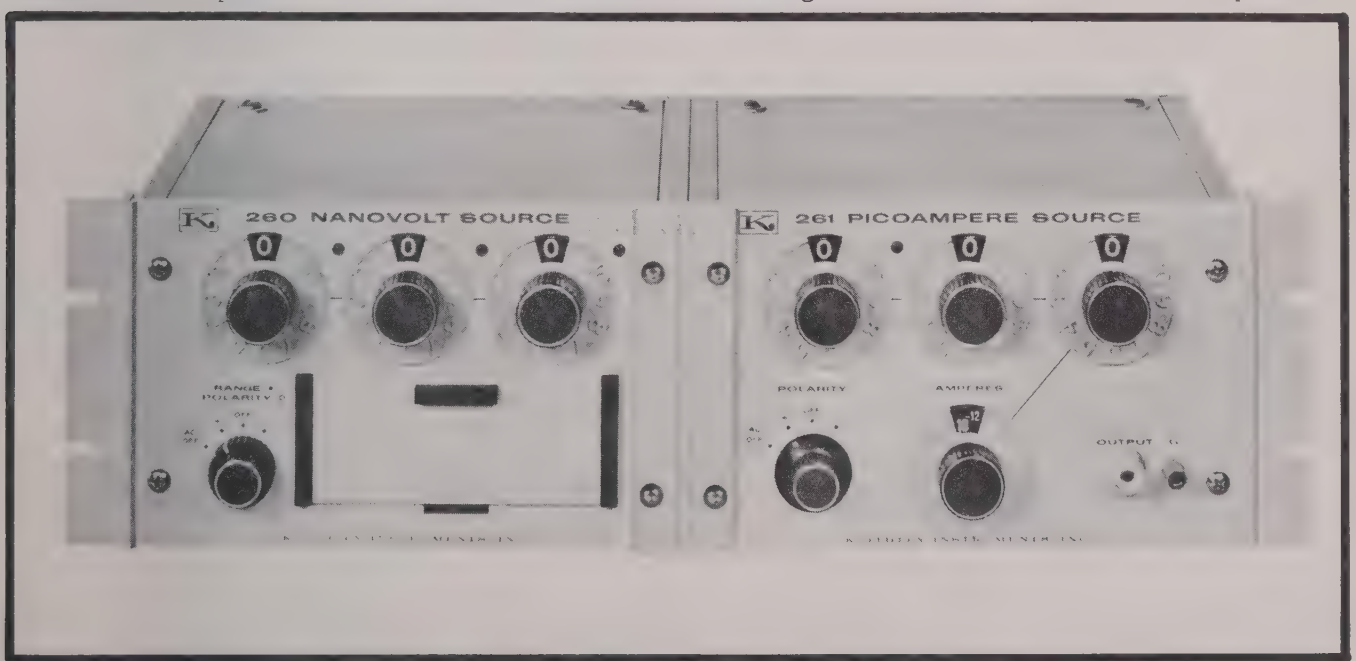


FIGURE 24. Keithley Model 4004A Dual Rack Mounting Kit containing the Keithley Models 260 and 261. The 4004A Kit also converts the Model 240A to rack mounting.

SECTION 7. REPLACEABLE PARTS

7-1. REPLACEABLE PARTS LIST. The Replaceable Parts List describes the components of the Model 240A and its accessories. The List gives the circuit designation, the part description, a suggested manufacturer, the manufacturer's part number and the Keithley Part Number. The last column indicates the figure picturing the part. The name and address of the manufacturers listed in the "Mfg. Code" column are in Table 10.

7-2. HOW TO ORDER PARTS.

a. For parts orders, include the instrument's model and serial number, the Keithley Part Number, the circuit designation and a description of the part. All structural parts and those parts coded for Keithley manufacture (80164) must be ordered through Keithley Instruments, Inc. or its representatives. In ordering a part not listed in the Replaceable Parts List, completely describe the part, its function and its location.

b. Order parts through your nearest Keithley representative or the Sales Service Department, Keithley Instruments, Inc.

amp	ampere	MtF	Metal Film
		My	Mylar
CerD	Ceramic, disc		
Comp	Composition	Ω	ohm
DCb	Deposited Carbon	p	pico (10^{-12})
EMC	Electrolytic, metal cased	Ref	Reference
		req'd	required
f	farad		
Fig.	Figure	μ	micro (10^{-6})
k	kilo (10^3)	v	volt
M or meg	mega (10^6) or megohms	w	watt
Mil. No.	Military Type Number	WW	Wirewound
Mfg.	Manufacturer		

TABLE 9. Abbreviations and Symbols.

MODEL 240A REPLACEABLE PARTS LIST

(Refer to Schematic Diagram 19197D for circuit designations)

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
C101	0.1 μf	200 v	My	02777	P-12M	C66-.1M	16
C102	.02 μf	600 v	CerD	72982	ED-.02	C22-.02M	18
C103	100 pf	600 v	CerD	72982	ED-100	C22-100P	18
C104	20 μf	450 v	EMC	37942	FP 144	C36-20M	16
C105	20 μf	450 v	EMC	37942	FP 144	C36-20M	16
C106	20 μf	450 v	EMC	37942	FP 144	C36-20M	16
C107	20 μf	450 v	EMC	37942	FP 144	C36-20M	16
C108	20 μf	450 v	EMC	37942	FP 144	C36-20M	16
C109	20 μf	450 v	EMC	37942	FP 144	C36-20M	16
C110	.033 μf	1600 v	My	14655	MGT S33	C43-.033M	16
C111	40 μf	350 v	EMC	14659	TVL 1621	C32-40M	16
C112	40 μf	350 v	EMC	14659	TVL 1621	C32-40M	16
C113	.047 μf	1600 v	My	14655	DMPS 16547	C87-.047M	20
C114	.01 μf	1600 v	My	14655	MGT-S1	C43-.01M	20
C115	.02 μf	600 v	CerD	72982	ED-.02	C22-.02M	16
C116	.02 μf	600 v	CerD	72982	ED-.02	C22-.02M	16

DIODES

Circuit Desig.	Type	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
D101	Zener	1N4747	04713	DZ-25	18
D102	Silicon	1N645	01295	RF-14	18
D103	Silicon	1N645	01295	RF-14	18
D104	Silicon	1N645	01295	RF-14	18
D105	Zener	1N936	04713	DZ-5	18
D106	Zener	1N4754	04713	DZ-26	18
D107	Silicon	1N645	01295	RF-14	18
D108	Silicon	1N3253	80164	17459A	18
D109	Silicon	1N3253	80164	17459A	18
D110	Silicon	HW3G	72982	RF-29	16
D111	Silicon	HW3G	72982	RF-29	16
D112	Silicon	1N3255	02735	RF-17	16
D113	Silicon	1N3255	02735	RF-17	16
D114	Silicon	1N645	01295	RF-14	18

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfg. Code	Keithley Part No.	Fig. Ref.
DS101	Pilot Light, ON (Mfg. No. 2100)	91802	PL-34	2
DS102	Pilot Light, OVERLOAD (Mfg. No. 2100)	91802	PL-35	2
F101	Fuse, slow blow, .75 amp, 250 v (Mfg. Type MDL)	71400	FU-19	
F101	Fuse, slow blow, .375 amp, 250 v (Mfg. Type MDL)	71400	FU-19	
---	Fuse holder (Mfg. No. 342012)	75915	FH-3	
J101	Receptacle, uhf, Input, (Mil. No. SO-239A)	91737	CS-64	15
---	Plug, uhf, Mate of J101 (Mil. No. 49190)	91737	CS-49	
---	Dust Cap, 2 req'd (Mfg. No. EC-10)	99017	CAP-1	
J102	Receptacle, uhf, output (Mil. No. SO-239A)	91737	CS-64	2
---	Plug, uhf, Mate of J102 (Mil. No. 49190)	91737	CS-49	
J103	Binding Post (Mfg. No. 33-286)	08811	BP-15	2
P101	Cord Set, 6 feet (Mfg. No. 4638-13)	93656	CO-5	
S101	Toggle Switch, SPST, ON (Mfg. No. 20994LH)	04009	SW-4	2
S102	Slide Switch, 117-234 v	80164	SW-151	
S103	TRIM Control Knob Assembly	80164	17322A	2
---	Trim Potentiometer, R135	71450	RP53-1.65K	
S104	Rotary Switch, X100 Output Volts	80164	SW-213	2, 14
---	Dial Assembly, X100 (0 - 11)	80164	19196A	
S105	Rotary Switch, X10 Output Volts	80164	SW-211	2, 14
---	Dial Assembly, X10 (0 - 10)	80164	14829A	
S106	Rotary Switch, X1 Output Volts	80164	SW-211	2, 14
---	Dial Assembly, X1 (0 - 10)	80164	14829A	
S107	Rotary Switch less components, OUTPUT	80164	SW-212	2
---	Switch Assembly with components, Output	80164	19467B	
---	Knob Assembly, Output	80164	17322A	
T101	Transformer	80164	TR-94	16

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R101	470 Ω	10%, 1/2 w	Comp	01121	EB	R1-470	17
R102	100 Ω	1%, 1/2 w	MtF	07716	CEC	R94-100	19
R103	2.7 kΩ	10%, 5 w	WW	05766	FRL-5	R131-2.7K	
R104	15 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-15K	19
R105	4.99 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-4.99K	19

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R106	8.06 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-8.06K	19
R107	8.2 kΩ	10%, 1/2 w	Comp	01121	EB	R1-8.2K	19
R108	680 kΩ	10%, 1/2 w	Comp	01121	EB	R1-680K	19
R109	10 kΩ	10%, 1/2 w	Comp	01121	EB	R1-10K	19
R110	47 kΩ	10%, 1/2 w	Comp	01121	EB	R1-47K	19
R111	33 kΩ	10%, 1/2 w	Comp	01121	EB	R1-33K	19
R112	120 kΩ	10%, 1/2 w	Comp	01121	EB	R1-120K	19
R113	1.5 MΩ	1%, 1/2 w	MtF	07716	CEC	R94-1.5M	19
R114	2 kΩ	20%, 2 w	WW	71450	INS 115	RP50-2K	19
R115	*1.3 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-1.3K	19
R116	1 kΩ	10%, 1/2 w	Comp	01121	EB	R1-1K	19
R117	500 Ω	20%, 2 w	WW	71450	INS 115	RP50-500	19
R118	8.25 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-8.25K	19
R119	301 Ω	1%, 1/2 w	MtF	07716	CEC	R94-301	19
R120	301 Ω	1%, 1/2 w	MtF	07716	CEC	R94-301	19
R121	301 Ω	1%, 1/2 w	MtF	07716	CEC	R94-301	19
R122	12 kΩ	10%, 2 w	Comp	01121	HB	R3-12K	17
R123	40.2 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-40.2K	19
R124	20 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-20K	19
R125	187 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-187K	19
R126	10 kΩ	20%, 2 w	WW	71450	INS 115	RP50-10K	19
R127	8.06 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-8.06K	19
R128	22.1 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-22.1K	19
R129	4.7 kΩ	10%, 1/2 w	Comp	01121	EB	R1-4.7K	19
R130	220 kΩ	10%, 1/2 w	Comp	01121	EB	R1-220K	19
R131	4.02 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-4.02K	19
R132	56 kΩ	10%, 1 w	Comp	01121	GB	R2-56K	19
R133	1 MΩ	1%, 1/2 w	MtF	07716	CEC	R94-1M	19
R134	1 MΩ	1%, 1/2 w	MtF	07716	CEC	R94-1M	19
R135	1.65 kΩ	10%, 1/2 w	DCb	71450	VF-N45	RP53-1.65K	15
R136	100 Ω	10%, 1/4 w	Comp	01121	CB	R76-100	17
R137	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	17
R138	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	17
R139	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	17
R140	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	17
R141	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	17
R142	470 kΩ	10%, 1/2 w	Comp	01121	EB	R1-470K	17
R143	1.4 kΩ	1%, 1/2 w	MtF	07716	CEC	R94-1.4K	19

*Nominal value, factory adjusted.

RESISTORS (Cont'd)

Circuit Desig.	Value	Rating	Type	Mfg. Code	Mfg. Part No.	Keithley Part No.	Fig. Ref.
R144	47 Ω	5%, 3 w	WW	44655	4400	R92-47	17
R145	1.75 kΩ	5%, 10 w	WW	44655	1-3/4-D-57-F	R5-1.75K	17
R146	1 MΩ	10%, 1/2 w	Comp	01121	EB	R1-1M	17
R147	Not Used						
R148	33 Ω	10%, 1 w	Comp	01121	GB	R2-33	20
R149	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R150	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R151	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R152	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R153	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R154	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R155	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R156	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R157	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R158	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R159	100 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-100K	20
R160	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R161	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R162	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R163	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R164	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R165	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R166	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R167	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R168	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R169	10 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-10K	20
R170	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R171	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R172	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R173	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R174	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R175	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R176	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R177	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R178	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R179	1 kΩ	.5%, 1/2 w	MtF	07716	CEC	R61-1K	20
R180	220 kΩ	10%, 1 w	Comp	01121	GB	R2-220K	15
R181	100 kΩ	10%, 1/2 w	Comp	01121	EB	R1-100K	19
R182	2 kΩ	10%, 5 w	WW	05766	FRL-5	R131-2K	17
R183	100 Ω	10%, 1/4 w	Comp	01121	CB	R76-100	19

TRANSISTORS

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
Q101	2N1381	01295	TG-8	18
Q102	2N398A	02735	TG-13	18
Q103	A1380	73445	TG-32	18
Q104	A1380	73445	TG-32	18
Q105 (1)	A1380	80164	19447A	18
Q106 (1)	A1380	80164	19447A	18
Q107	A1380	73445	TG-32	18
Q108	A1380	73445	TG-32	18
Q109	A1380	73445	TG-32	18
Q110	2N398A	02735	TG-13	18

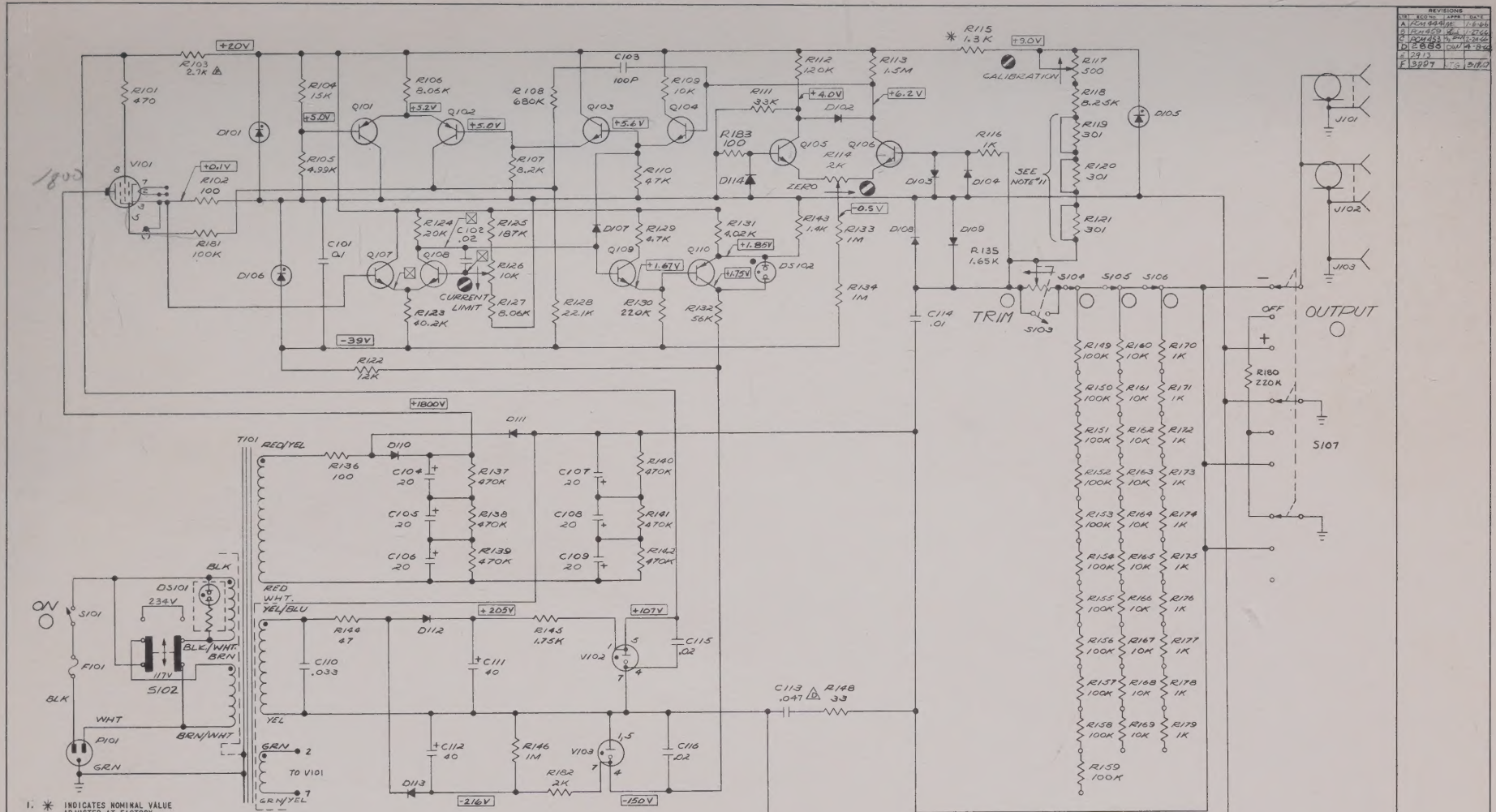
VACUUM TUBES

Circuit Desig.	Number	Mfg. Code	Keithley Part No.	Fig. Ref.
V101	8068	03507	EV-8068	14
V102	OB2	86684	EV-OB2	16
V103	OA2	86684	EV-OA2	16

(1) Transistors Q105 and Q106 are matched (part no. 19447A); order only as a pair from Keithley Instruments, Inc.

01121	Allen-Bradley Corp. Milwaukee, Wis.
01295	Texas Instruments, Inc. Semiconductor-Components Division Dallas, Texas
02735	Radio Corp. of America Commercial Receiving Tube and Semiconductor Division Somerville, N.J.
02777	Hopkins Engineering Co. San Fernando, Calif.
03507	G. E. Power Tube Dep't. Schenectady, New York
04009	Arrow-Hart and Hegeman Electric Co. Hartford, Conn.
04713	Motorola, Inc. Semiconductor Product Division Phoenix, Arizona
05766	Tru-Seal Div. of Flick-Reedy Corp. Melrose Park, Ill.
07716	International Resistance Co. Burlington, Iowa
08811	G-L Electronics Co., Inc. Camden, New Jersey
14655	Cornell-Dubilier Electric Corp. Newark, N.J.
14659	Sprague Electric Co. Visalia, Calif.
15238	ITT Components Selenium Dept. Mfg. Div. of ITT Semiconductor Inc. Lawrence, Mass
37942	Mallory, P. R. and Co., Inc. Indianapolis, Ind.
44655	Ohmite Mfg. Co. Skokie, Ill.
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.
71450	CTS Corp. Elkhart, Ind.
72982	Erie Technological Products, Inc. Erie, Pa.
73445	Amperex Electronic Co. Division of North American Philips Co., Inc. Hicksville, N.Y.
75915	Littelfuse, Inc. Des Plaines, Ill.
80164	Keithley Instruments, Inc. Cleveland, Ohio
86684	Radio Corp. of America Electronic Components and Devices Harrison, N.J.
91737	Gremar Mfg. Co., Inc. Wakefield, Mass.
91802	Industrial Devices Inc. Edgewater, N. J.
93656	Electric Cord Co. Caldwell, N. J.
99017	Protective Closures Co., Inc. C. A. Plugs Div. Buffalo, New York

TABLE 10. Code List of Suggested Manufacturers. Based on Federal Supply Code for Manufacturers, Cataloging Handbook H4-1.



1. * INDICATES NOMINAL VALUE ADJUSTED AT FACTORY.
2. ○ INDICATES FRONT PANEL CONTROL.
3. ⊘ INDICATES FRONT PANEL SCREWDRIVER ADJ.
4. ⊘ INDICATES REAR PANEL SCREWDRIVER ADJ.
5. ● INTERNAL SCREWDRIVER ADJ.
6. M — MEGOHM
7. K — 1000 OHM
8. pf — PICOFARAD
9. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS RESPECTIVELY UNLESS OTHERWISE NOTED.
10. ↑ — CLOCKWISE ROTATION
11. JUMPERS CLIPPED AT FACTORY FOR ADJUSTMENT.
12. VOLTAGE READINGS TAKEN WITH RESPECT TO CHASSIS GROUND:
    VOLTAGE CONTROLS AT 000.
    TRIM CONTROL AT CAL POSITION.
    OUTPUT CONTROL AT (-) NEGATIVE POSITION.
    60 cps, 117 VOLT POWER LINE.
    USING A 200 M VOLTMETER.
    READINGS TO BE WITHIN ± 15%.
    READINGS MARKED ☒, SEE INSTRUCTION MANUAL.

REFERENCE DESIGNATIONS NOT USED			

HIGHEST REFERENCE DESIGNATION				
R183	C117	Q110	V103	S107
J103	GL101	P101	F101	DS102
D114				

REVISIONS			
DIST	ECO No.	APPR.	DATE
A	FCM 44415E		1-18-66
B	FCM 4459		1-27-66
C	FCM 4533	PMD	3-4-66
D	2885	CWM	4-8-66
E	2913		
F	3207	TG	9-11-67

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED			DRN J A F	DATE 2-4-66	KEITH LEY INSTRUMENTS	TITLE SCHEMATIC, 240A HIGH VOLTAGE SUPPLY
FRAC	DEC	ANG	JWW	4-8-66		
± 1/64	± .005	±	DWH	4/11/66		
			DWH	4-8-66		19197D
DO NOT SCALE			JWW	4-8-66		

240A 1

KEITHLEY INSTRUMENTS, INC.
12415 EUCLID AVENUE
CLEVELAND, OHIO 44106